THE

NAVAL CONSTRUCTOR:

A VADE MECUM

OF

SHIP DESIGN FOR STUDENTS, NAVAL ARCHITECTS, SHIPBUILDERS AND OWNERS, MARINE SUPERINTENDENTS, ENGINEERS AND DRAUGHTSMEN.

BY

GEORGE SIMPSON,

MEMBER OF THE INSTITUTION OF NAVAL ARCHITECTS,
ASSOC. MEMBER AMERICAN SOCIETY OF NAVAL ENGINEERS.

Third Edition, Revised and Enlarged.

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PREFACE TO FIRST EDITION.

THIS HANDBOOK has been prepared with the object of supplying a ready reference for those engaged in the design, construction, or maintenance of ships, — such a work as should give simply and concisely, information on most of the points usually dealt with in the theory and practice of marine architecture, and in addition much that is new and original. Under the latter heading should be included the chapter on Design and many of the tables of standardized fitting details, etc.

The Freeboard tables have been explained and their application simplified by working out examples embracing the various types to which freeboards are assigned, including the modern shelter decker, for which rules have recently been issued.

While it would have been possible to enlarge greatly on what the author has attempted, it has been deemed prudent at present to restrict somewhat the scope of the book, although at that, it will be found much more comprehensive in its character than existing works on naval architecture.

It has been the author's aim to eliminate all obsolete matter and antiquated data, and to bring the book right in line with present day requirements.

How nearly he has come to this ideal will be shown by the reception accorded by the profession.

His thanks are especially due to Ernest H. Rigg, A. M. I. N. A., for valuable assistance in the preparation of the chapter on Freeboard, to Jas. A. Thomson, M. I. N. A., for aid in the reading of proofs, and to the publishers for their hearty co-operation.

GEORGE SIMPSON.

647 RICHMOND TERRACE, MARINER HARBOR,
NEW YORK CITY, MAY, 1904.

PREFACE TO THIRD EDITION.

THE preceding editions of this handbook were received so favorably that it was decided to enlarge the third edition by the addition of further "unified" details such as made the earlier editions noteworthy. There has also been included much new matter dealing with ventilation and other subjects, while other portions of the book have been revised and brought up-to-date.

It is hoped that in its enlarged form "The Naval Constructor" will continue to occupy its present position as a daily book of reference for those engaged in the design, construction and maintenance of ships.

GEORGE SIMPSON.

17 Battery Place,
NEW YORK CITY,
1ST MAY, 1914.

CONTENTS.

Section I.—Ship Calculations.

Section II. — Strength of Materials.

Section III. — Fittings and Details.

SYMBOLS COMMON IN NAVAL ARCHITECTURE USED IN THIS BOOK.

A . . . . Area of load water plane.
S.A. . . . Sail area in square feet.
C.E. . . . Centre of effort of sail plan.
(CE)$\rightarrow$ . . Distance of centre of effort forward of centre of immersed lateral plane.
a . . . . . Coefficient of fineness of load water line $= \dfrac{A}{L \times B}$.
b . . . . . Bilge diagonal coefficient.
Bm . . . Moulded breadth of ship.
Bx . . . . Extreme breadth of ship.
Bw . . . . Water-line breadth of ship.
β . . . . . Coefficient of midship section area $= \dfrac{✕ A}{B \times d}$.
B . . . . Centre of gravity of displacement (centre of buoyancy).
C.B. . . . Centre of gravity of displacement from aft perpendicular.
G . . . . Centre of gravity of ship above base.
C.G. . . Centre of gravity of ship and engines.
H . . . . Moulded depth to upper deck.
D . . . . Displacement in tons of salt water (gross).
V . . . . Displacement in cubic feet (volume).
$D+$ . . . Displacement in tons at load draught.
$D-$ . . . Displacement in tons at light.
$D\rightarrow$ . . . Displacement of fore body.
$\leftarrow D$ . . . Displacement of after body.
δ . . . . . Coefficient of fineness of displacement (block coefficient).
ϵ . . . . . Relation coefficient.
F . . . . Freeboard from statutory deck line.
Fr . . . . Freeboard to top of rail amidship.
g . . . . . Coefficient of centre of gravity $= \dfrac{G}{H}$.
A.P. . . After perpendicular (after side of rudder post).
F.P. . . . Forward perpendicular (fore side of stem at upper deck).
✕ . . . . Indicates *the half-length between* perpendiculars and is *the sign of the mid-section* or "dead flat."

⨯ *A* . . . Mid-section area.

M.C. . . Height of transverse metacentre above base.

G.Z. . . . . Stability lever.

G.M. . . Height of transverse metacentre above centre of gravity.

B.M. . . Height of transverse metacentre above centre of buoyancy.

L.M.C. . Longitudinal metacentre above base.

$\tilde{G}$ . . . . Centre of gravity below L.W.L.

$\underset{\sim}{G}$ . . . . Centre of gravity above L.W.L.

p . . . . Prismatic coefficient.

I.H.P. . Indicated horse power.

E.H.P. . Effective horse power.

N.P. . . Nominal horse power.

B.P. . . . Length of ship between perpendiculars.

W.L. . . Length of ship on load water line.

wl . . . . Water line.

O.A. . . . Length of ship over all.

R . . . . Placed before dimensions indicates that these are the registered or tonnage dimensions.

I . . . . . Moment of inertia of load water plane.

M . . . . Metacentre and moment.

M″ . . . Moment to alter trim one inch at load line.

O . . . . On drawings locates the intersection of projected water line with the elevation.

⊙ . . . . Centre of gravity, or moment about centre.

Ⓦ . . . Centre of gravity of water line.

⊗ . . . Centre of gravity of mid-section area.

(CE) . . . Centre of gravity of sail plan, or centre of effort.

y . . . . . Ordinates or stations.

x . . . . . Common interval or abscissa between ordinates.

W.S. . . Area of wetted surface.

R . . . . Resistance.

½ *G*, or *U*, Half-girth of midship section (Lloyd's).

d . . . . . Draught of water moulded (mean).

d→ . . . Draught of water forward
←*d* . . . Draught of water aft } to bottom of keel.
⊖ . . . . Mean draught

P . . . Power.

V . . . . Speed in knots per hour.

C . . . . Admiralty constant $= \dfrac{D^{\frac{2}{3}} \times V^{3}}{\text{I.H.P.}}$.

⅌ . . . . Per.

Symbols Common in Naval Architecture

$\text{℔}''$ . . . Per inch ; also tons per inch of immersion at L. W. L.
$\square'$ . . . . Square foot.
$\square''$. . . . Square inch.
ϕ . . . . . Cubic foot.

Algebraical Signs.

$+$ Plus, addition. Positive. Compression.	◓ Semicircle.
$-$ Minus, subtraction. Negative. Tension.	◱ Quadrant.
$=$ Equal to.	∞ Infinity.
$\neq$ Unequal to.	$\frown$ Arc.
$>$ Greater than.	$\sim$ Difference.
$\ngtr$ Not greater than.	( ) [ ] { } Vincula.
$<$ Less than.	c Constant.
$\nless$ Not less.	d Differential.
$\times$ By. Multiplied by	$\int$ Integration.
$::$ Multiplied by. Ratio. Is to.	f Functions.
$:$ So is. As (ratio). Divided by.	g Gravity.
$\perp$ Perpendicular to.	k Coefficient.
$\parallel$ Parallel to.	n Any number.
$\nparallel$ Not parallel.	α An angle.
$\because$ Because.	δ Variation.
$\therefore$ Therefore.	Δ Finite difference.
$\angle$ Angle.	θ, ϕ Any angles.
∟ Right angle.	π Ratio of circumference to diameter of circle.
$\triangle$ Triangle.	ρ Radius.
▱ Parallelogram.	Σ Sum of finite quantities.
$\square$ Square.	$\sqrt{\ }$ Square root.
○ Circumference.	$\sqrt[3]{\ }$ Cube root.
$\odot$ Circle.	$\sqrt[n]{\ }$ nth root.

THE

NAVAL CONSTRUCTOR

CHAPTER I.

DISPLACEMENT (D).

The displacement of any floating body whether it be a ship, a barrel, a log of lumber or, as in the case of the great Philosopher who first discovered its law, the human person, is simply the amount of water forced or squeezed aside by the body immersed. The Archimedian law on which it is based may be stated as:—*All floating bodies on being immersed in a liquid push aside a volume of the liquid equal in weight to the weight of the body immersed.* From which it will be evident that the depth to which the body will be immersed in the fluid will depend entirely on the density of the same, as for example in mercury the immersion would be very little indeed compared with salt water, and slightly less in salt water than in fresh. It is from this principle that we are enabled to arrive at the exact weight of a ship, because it is obvious that if we can determine the number of cubic feet, or *volume* as it is called, in the immersed body of a ship, then, knowing as we do that there are 35 cubic feet of salt water in one ton, this volume divided by 35 will equal the *weight* or displacement in tons of the vessel. If the vessel were of box form, this would be a simple enough matter, being merely the length by breadth by draught divided by 35, but as the immersed body is of curvilinear form, the problem resolves itself into one requiring the application of one of a number of ingenious methods of calculation, the principal ones in use being (1) The Trapezoidal Rule, (2) Simpson's Rules, and (3) Tchibyscheff's method.

Simpson's First Rule.

The calculation of a curvilinear area by this rule is usually defined as dividing the base into a suitable *even* number of equal parts, erecting perpendicular ordinates from the base to the curve, and after measuring off the lengths of these ordinates, to the sum

of the end ones, add four times the odd and twice the even ordinates. The total sum multiplied by one third the common interval between these ordinates, will produce the area. It should, however, be stated that the number of equal parts need not necessarily be even, and as it is sometimes desirable to calculate the area to an *odd* ordinate by taking the sum of the first ordinate and adding to it four times the odd ones, and twice the last as well as the even ordinates into one third the common interval, the area may be calculated accurately. In the foregoing definition it should be noted that the first ordinate is numbered "0," and that the number of intervals multiplied by 3 should equal the sum of the multipliers.

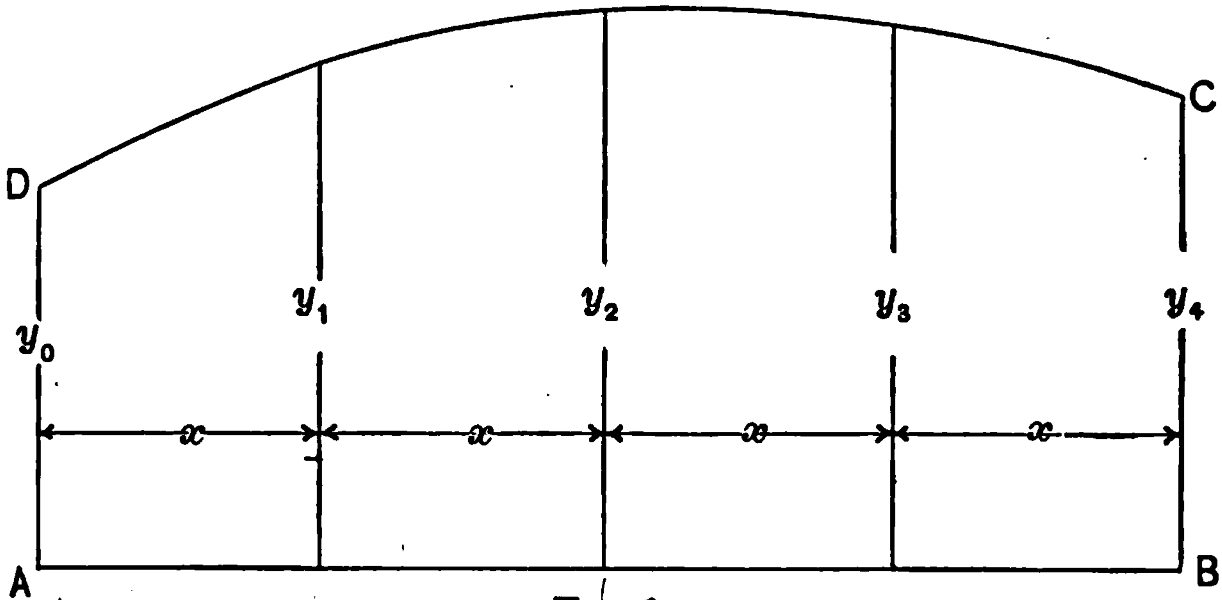


FIG. 1.

$$\text{Area of } ABCD = \frac{x}{3}(y_0 + 4\,y_1 + 2\,y_2 + 4\,y_3 + y_4).$$

And if half ordinates be inserted between y_0 and y_1 and between y_3 and y_4 we should then have :—

$$\text{Area} = \frac{x}{3}(\tfrac{1}{2}\,y_0 + 2\,y_{\frac{1}{2}} + 1\tfrac{1}{2}\,y_1 + 4\,y_2 + 1\tfrac{1}{2}\,y_3 + 2\,y_{3\frac{1}{2}} + \tfrac{1}{2}\,y_4).$$

Should, however, we desire to calculate the area embraced within the limits of y_3 only, omitting the half ordinate $y_{\frac{1}{2}}$, then :—

$$\text{Area} = \frac{x}{3}(y_0 + 4\,y_1 + 2\,y_2 + 2\,y_3).$$

So that it is immaterial what subdivision of parts we may use as long as the multiplier is given the relative value to the space it represents as exemplified in the subjoined table. It will be obvious that we may also give multiplier only half its value, as

$$\tfrac{1}{2}\,y_0 + 2\,y_1 + 1\,y_2 + 2\,y_3 + \tfrac{1}{2}\,y_4,$$

and multiply the sum by $\frac{2}{3}$ of x, which will be found the more convenient way to use the rule, involving as it does figuring with smaller values.

Multipliers for Subdivided Intervals.

Ordinates,	0	$\frac{1}{2}$	1	2	3	4	5	$5\frac{1}{2}$							
Multipliers,	$\frac{1}{2}$	2	$1\frac{1}{2}$	4	2	4	$1\frac{1}{2}$	1							
Ordinates,	0	1	2	$2\frac{1}{4}$	3	$3\frac{1}{4}$	$3\frac{1}{2}$	$3\frac{3}{4}$	4	$4\frac{1}{8}$	$4\frac{1}{4}$	$4\frac{1}{2}$	$4\frac{3}{4}$	$4\frac{7}{8}$	5
Multipliers,	1	4	$1\frac{1}{2}$	2	$\frac{1}{2}$	1	$\frac{1}{2}$	1	[illegible]	[illegible]	$\frac{7}{8}$	[illegible]	$\frac{1}{3}$	[illegible]	[illegible]
Ordinates,	0	$\frac{1}{2}$	1	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	4	5	$5\frac{1}{2}$	6	$6\frac{1}{4}$	$6\frac{1}{2}$	$6\frac{3}{4}$	7
Multipliers,	$\frac{1}{2}$	2	1	2	1	2	$1\frac{1}{2}$	4	$1\frac{1}{2}$	2	$\frac{3}{4}$	1	$\frac{1}{2}$	1	$\frac{1}{4}$
Ordinates,	0	1	2	$2\frac{1}{3}$	$2\frac{2}{3}$	3	$3\frac{1}{3}$	$3\frac{2}{3}$	4	5	6	$6\frac{1}{2}$	7	$7\frac{1}{2}$	8
Multipliers,	1	[illegible]	$1\frac{1}{3}$	$1\frac{1}{3}$	$\frac{2}{3}$	$1\frac{1}{3}$	$\frac{2}{3}$	$1\frac{1}{3}$	$1\frac{1}{3}$	4	$1\frac{1}{2}$	2	1	2	$\frac{1}{2}$

As proof of the rule let us deal with an example:

$$\text{Area } ABCD = \frac{x}{3}(y_0 + 4y_1 + y_2).$$

Assume curve DFC is part of a common parabola; area $DKCFD$ is $\frac{2}{3}$ area of parallelogram. Join DC, and draw parallel

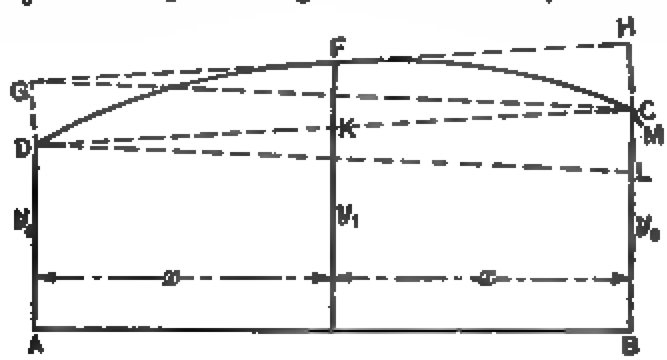


FIG. 2.

to GH touching curve. If DFC be part of parabola area, DFC is $\frac{2}{3}$ of parallelogram $DCHG$.

$$EK = \tfrac{1}{2}(y_0 + y_1). \qquad FK = y_1 - \frac{y_0 + y_2}{2}.$$

Parallelograms on same base and between same parallels are equal. Draw through G and H two lines parallel to base as GM and DL, then area

$$\begin{aligned} DCHG &= \text{area } DLMG \\ &= 2x \times DG \\ &= 2x \times FK \\ &= 2x\left(y_1 - \frac{y_0 + y_2}{2}\right) \end{aligned}$$

$$\left.\begin{array}{r} \text{Area } DFC = \tfrac{2}{3} \text{ of above} = \dfrac{4\,x}{3}\left(y_1 - \dfrac{y_0 + y_2}{2}\right) \\ \text{Area } ABCKD = 2\,x\left(\dfrac{y_0}{2} + \dfrac{y_2}{2}\right) \end{array}\right\} =$$

$$\text{Whole area } 2\,x\left(\frac{y_0}{2} + \frac{y_2}{2}\right) + \frac{4\,x}{3}\left(y_1 - \frac{y_0 + y_2}{2}\right)$$

$$= \frac{x}{3}\,(y_0 + 4\,y_1 + y_2).$$

Simpson's second rule for determining areas bounded by a parabola of the third order and the "five eight" rule applicable to the calculation of one of the subdivided areas are given in most text-books, but are omitted here as superfluous, Simpson's first rule being adaptable to either of these cases, so that for all ship calculations where areas, volumes, or moments are required, the first rule, or as hereafter explained Tchibyscheff's rule, are recommended.

We have seen, then, how the area or surface may be calculated by this rule, and as the volume is the area by the thickness, it will be evident that if the areas be calculated at various levels or water lines, as shown in the figure, and these areas in turn treated as a curve and integrated by means of the rule, that the result will be the volume of the body.

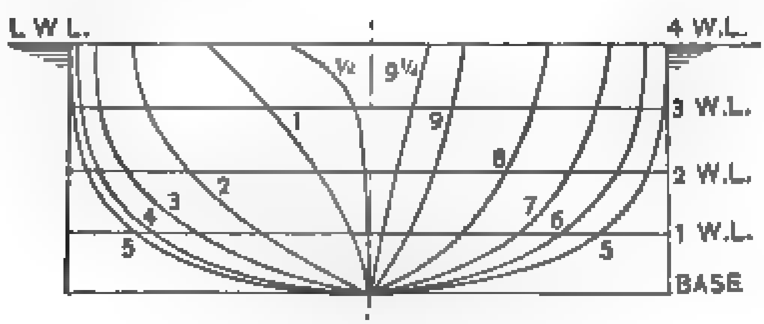


FIG. 3.

Let the Figs. 3 and 4 represent the immersed half longitudinal body of a vessel 100 feet long by 12 feet broad submerged to 5 feet draught as represented by L.W.L. It is required to calculate the volume of water displaced by Simpson's first rule. The base line length between perpendiculars should be divided into an equal number of intervals, and as advocated in the chapter on Design, it will be well to have a definite number and retain same for all designs, as by so doing it will facilitate comparisons and working from one design to another. Ten such intervals with half-end ordinates is a very convenient division, and in this case

will give a common interval of 10 feet. The draught of 5 feet must likewise be subdivided into a certain number of equal intervals, which in this case we will fix at 4, so that

$$\frac{5 \text{ ft. draught}}{4} = 1.25 \text{ ft.}$$

interval between water lines. These divisions of water lines must be drawn across the body plan of ten sections, and the half breadths read off with a scale and tabulated as in table on following page.

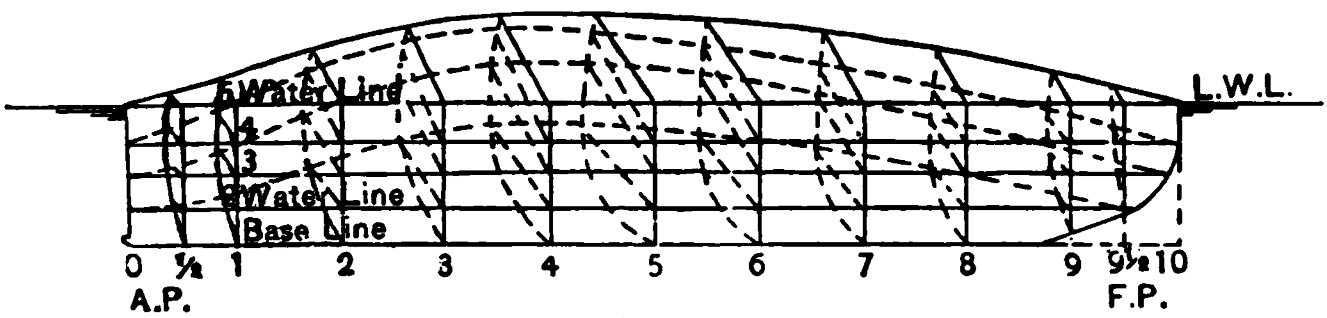


FIG. 4.

It should be stated in connection with the subdivision of the base line that the length taken for displacement is measured by some designers from the after side of body post *i.e.*, ignoring the propeller aperture ; and by others from the *fore* side of body post to the *after* side of stem omitting the moulded size of these forgings. Both of these methods are inaccurate besides leading to confusion, as, in the first case, the displacement of the propeller with its boss will equal the displacement cut out for aperture not to mention the volume of the rudder, which is rarely, if ever, taken into account. And in the second case the tiny amount of displacement added at the knuckle formed by the bearding line of plating when the length is taken to forward and after sides of stem and stern post respectively, is compensated for by the gudgeons on stern post. Therefore the most correct and also the most convenient length is from after side of rudder post to forward side of stem at load water line.

Where vessels have a very flat floor line a half water line should be taken between base line and first water plane, and the keel or bottom half-breadth given a value proportioned to the rise of floor line as in Fig. 5.

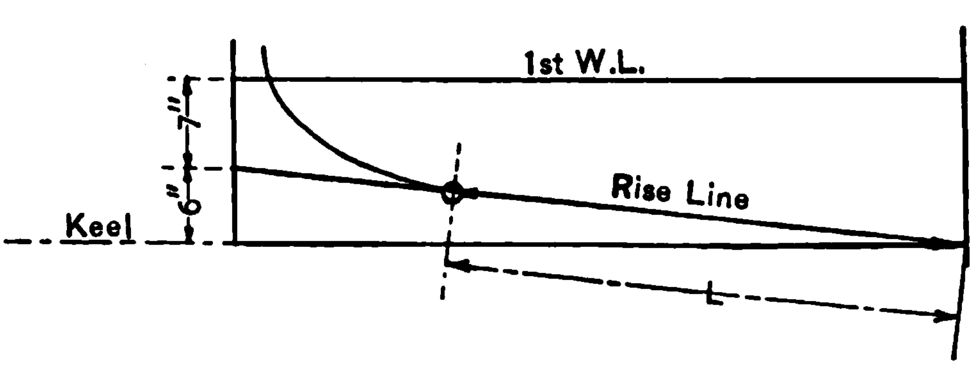


FIG. 5.

Required the half-breadth x at the keel for the displacement sheet, where 10 feet is the actual scaled length L, 6″ the rise of floor, 7″ the distance from the rise line to first water line at moulded half-breadth of ship and, of course, 13 inches the water line interval, then : —

$$13'' : 7'' :: 10 \text{ feet} : x.$$

$$\therefore\ x = 5.38 \text{ feet} = \text{bottom breadth.}$$

Displacement Table.

Water lines apart . . . 1.25′ Load draught . . . . 5.00′
Ordinates apart . . . . 10.00′ Displacement length, 100.00′

Ordinates.	Simpson's Multipliers.	Keel.		W L. 1.		W.L. 2.		W.L. 3.		W.L. 4.	
		Half-Breadths.	Products.	Half-Breadths	Products	Half-Breadths.	Products.	Half-Breadths	Products.	Half-Breadths.	Products.
0	$\frac{1}{4}$	.04	.01	.04	.01	.04	.01	.04	.01	.04	.01
$\frac{1}{2}$	1	.03	03	.08	.08	.18	.18	.43	.43	1.41	1.41
1	$\frac{3}{4}$	.02	.01	.16	.12	.73	.55	1.76	1 33	3.10	2.82
2	2	.02	.04	.92	1.84	2.35	4.70	3.78	7.56	4 81	9.62
3	1	02	02	2 13	2.13	4.03	4.03	5.16	5.16	5 56	5.56
4	2	.02	04	3.20	6 40	4.98	9 96	5.67	11.34	5.96	11.92
5	1	.02	.02	3.54	3.54	5.20	5.20	5.80	5.80	6.00	6.00
6	2	.02	.04	3 00	6 00	4.66	9.32	5.34	10.68	5.58	11.16
7	1	.02	.02	2 00	2.00	3 58	3 58	4 42	4 42	4 87	4 87
8	2	02	.04	1.25	2.50	2 28	4.56	3.04	6.08	3.57	7.14
9	$\frac{3}{4}$	.02	.01	.48	.36	1.00	.75	1 50	1.12	1.90	1.42
$9\frac{1}{2}$	1	.02	.02	.18	.18	.50	.50	.74	.74	.97	.97
10	$\frac{1}{4}$	. . .	.	. .	. .	. .	. .	.03	.01	03	.01
15 = 10 × 1.5	15 = Sum of Multipliers.	Sum of Products.	.30		26.16		43.34		54.68		62.41
			$\frac{1}{2}$		2(1)		1($\frac{1}{2}$)		2(1)		$\frac{1}{2}$
			.15	+	50 32	+	43.34	+	109.36	+	31.20 = 234.37

$$\frac{(\frac{2}{3}\text{ W.L. interval}) \times (\frac{2}{3}\text{ ordinate interval}) \times 2 \text{ (both sides)}}{35 \text{ (cub. ft. of S.W. in a ton)}} = \text{coeff.}$$

$$= \frac{(1.25 \times \frac{2}{3}) \times (10 \times \frac{2}{3}) \times 2}{35} = .315.$$

	234.37
	× .315
Displacement to W.L. 4	= 73.82
.15 + 50.32 + 43.34 + 54.68	= 148.49
	× .315
Displacement to W.L. 3	= 46.77 tons.
.15 + 50.32 + 21.62	= 72.09
	× .315
Displacement to W.L. 2	= 22.70 tons.
.15 + 25.16	= 25.31
	× .315
Displacement to W.L. 1	= 7.97 tons.

The displacement to the load water line being 73.82 tons it is useful to know what relation that weight bears to the vessel if she were of box section, in other words, the amount that has been cut off the rectangular block formed by the length, breadth, and draught, to fine it to the required form, or the *block* coefficient or coefficient of displacement represented by the symbol "δ". It will be evident that this coefficient may readily be computed by multiplying the length × breadth × draught, and dividing the product, which is the volume of the box in cubic feet, by 35 to get the tons displaced by the rectangular block. The displacement as calculated, divided by this result, will give the *block* coefficient "δ", or,

$$\frac{V}{L \times B \times d} = .432 \text{ nearly.}$$

The range of this coefficient for various types is given elsewhere in the Table of Element Coefficients.

Area of Water Plane.

	Keel.	W.L. 1.	W.L. 2.	W.L. 3.	W.L. 4.
Sum of products .	.30	25.16	43.34	54.68	62.41
$\frac{2}{3}$ common interval,	$6\frac{2}{3}$	$6\frac{2}{3}$	$6\frac{2}{3}$	$6\frac{2}{3}$	$6\frac{2}{3}$
Half-areas . . .	2.00	167.73	288.93	364.53	416.07
	2	2	2	2	2
Areas of water planes . . .	4.00	335.46	577.86	729.06	832.14

The area of any of the water planes in the specimen displacement table will simply be the sum of the products of the particular

water plane required, multiplied by $\frac{2}{3}$ the interval between ordinates. This product doubled will be the total area of both sides.

Tons per Inch of Immersion ($\frac{T}{I}''$).

It is useful to know the amount of displacement of the vessel for each inch of immersion at various draughts, as from this data small amounts of cargo taken out or placed on board can be accurately determined without reference to, or scaling from, the regular displacement curve. It will be seen that if A represents the area of water plane, that this surface multiplied by a layer 1 inch in thickness and divided by 12 will equal the *volume* of water displaced in cubic feet at the particular water plane dealt with, and that this volume divided by 35 will equal the displacement in tons for one inch, or in other words, the tons *per inch immersion*. Or,

$$A \times \frac{1}{12} = \frac{A}{12} \text{ cubic feet,}$$

and the weight of water in the layer

$$\frac{A}{12} \times \frac{1}{35} = \frac{A}{420} = \text{ tons per inch.}$$

Tons per inch immersion in salt water,

$$\frac{\text{area of water plane}}{420}.$$

Tons per inch immersion in fresh water,

$$\frac{\text{area of water plane}}{(12 \times 36) = 432}.$$

So that referring to the table we have been working out, we get:—

	Keel.	W.L. 1.	W.L. 2.	W.L. 3.	W.L. 4.
Area of water plane	4.00 ÷	335.46 ÷	577.86 ÷	741.06 ÷	832.14 ÷
12″ × 35 = ...	420	420	420	420	420
Tons per inch = .	.01	.79	1.37	1.76	1.98 S.W.

It is often necessary to estimate the tons per inch approximately, and for this purpose the coefficient of the load line or "a" is used. The method of arriving at this coefficient is explained in the chapter on design when the displacement is known.

It has a range of about .6 in fine vessels to .9 in exceptionally full ones. In the above example it is found to be

$$\frac{832.14}{\text{Length} \times \text{Breadth}} = \frac{832.14}{1200} = .694.$$

Therefore the tons per inch is equal to

$$\frac{L \times B \times .694}{420} = 1.98.$$

Its relation to the other element coefficients is

$$\alpha = \frac{\delta}{\epsilon . \beta}.$$

Immersion Passing from Salt to Fresh Water.

From what has been previously said it will be obvious that the draught of water, or immersion of a vessel, will undergo a change in passing from fresh water into the sea or *vice versa*, owing to the difference in density of the two liquids. If we take the case of the ship passing from salt water to fresh, the immersed volume will be in each case as follows: —

$$\begin{aligned} \text{Immersed volume in salt water} &= 35\ D, \\ \text{Immersed volume in fresh water} &= 36\ D, \end{aligned}$$

where D is the displacement in tons, which in the example we have been investigating equals 73.82 tons. Therefore the volume in cubic feet which the vessel has sunk on entering the fresh water is $36\ D - 35\ D = 2657 - 2584 = 73$ cubic feet. Let $T =$ tons per inch immersion in fresh water $\therefore$ area of water plane $= 432\ T$ and the extent to which the vessel will sink

$$= \frac{73}{432\ T} \text{ feet} = \frac{12 \times 73}{432\ T \text{ inches}} = \frac{73}{36\ T} = 1.02 \text{ inches.}$$

Inversely we have the amount that the vessel emerges in passing out of a river into the ocean. Thickness of the layer which vessel has risen in feet

$$= \frac{\text{Difference in volume } D}{\text{Area of the plane}},$$

and in inches,

$$\frac{\text{Difference in Volume } D \times 12}{\text{Area of water plane}} = \frac{12 \times 73}{420\ T} = \frac{73}{69.3} = 1.05 \text{ inches.}$$

This immersion and emersion is, of course, the mean amount as the vessel will also slightly change her trim due to the altered position of the centre of gravity of water plane, about which the ship's movements are pivotal.

Area of Midship Section ($\text{)(} A$).

The area of this, or any of the other sections on the displacement table, is calculated by taking the half-breadths of the water lines and integrating them as explained for water-line area. The sum of the products thus obtained is multiplied by $\frac{1}{3}$ the distance of water lines apart, and that result by 2 for both sides. Where the vessel has little rise of floor a half water line should be introduced, and the *bottom* half-breadth proportioned to the rise line, as pointed out in the displacement calculation. In the example with which we are dealing, however, the vessel has considerable rise, so that this subdivision has been omitted.

Ordinate.	Keel.	W.L. 1.	W.L. 2.	W. L. 3.	W.L. 4.
"5"	Half-Breadth.	Half-Breadth.	Half-Breadth.	Half-Breadth.	Half-Breadth.
	.02	3.54	5.20	5.80	6.00
Simpson's Multipliers	$\frac{1}{2}$	2	1	2	$\frac{1}{2}$

.01 + 7.08 + 5.20 + 11.60 + 3.00 = 26.89

$\frac{1}{3}$ distance between water lines . . . . × .83
Half area of midship section to L.W.L. . . . =22.31
For both sides . . . . × 2
Midship section area . . . . =44.62

The coefficient of this area, or β, is a very important element of the design as explained elsewhere, and is obtained by dividing the midship area by the area of the rectangle formed by the molded breadth and the draught, or

$$\frac{\text{Mid. area}}{\text{Breadth} \times \text{draught}} = \frac{44.62}{60} = .743 \text{ coefficient of mid. area.}$$

Its relation to the midship-section cylinder or prismatic coefficient "p" is $\frac{\delta}{\beta}$, and "p" is equal to the volume of displacement divided by the length × mid. area, thus: —

$$p = \frac{V}{L \text{)(} A} = \frac{L \times B \times d \times \delta}{L \times B \times d \times \beta} = \frac{\delta}{\beta} = \text{prismatic coefficient,}$$

and consequently, $\beta = \frac{\delta}{p}$.

Centre of Buoyancy (C.B.).

The centre of buoyancy of the displaced water is simply its centre of gravity, and its location below the load-water line is greater or less in accordance with the form of the immersed body. This distance may be found by dividing the under-water part into a number of planes parallel to the load line, and multiplying the volumes, lying between these water planes, by their depth below load-water line. These moments divided by the displacement volume will give the location of centre of buoyancy below load-water plane. So that by taking the functions of the products at each water plane on the sheet we have been working and multiplying them by the number of the water line they represent below L.W.L., and dividing the sum of those products by the sum of the functions referred to, we shall have the number of water-line intervals (or fraction of an interval), which the C.B. is below load-water line. This result, multiplied by the common interval between water lines, will give the required distance in feet.

	Keel.		W.L. 1.		W.L. 2.		W.L. 3.		W.L. 4.		
Functions of products	.15	+	50.32	+	43.34	+	109.36	+	31.20	=	234.37
	4		3		2		1		0		
	.60	+	150.96	+	86.68	+	109.36	+	0	=	347.60
							347.6 ÷ 234.37			=	1.49
											×
Water lines apart										=	1.25
Centre of buoyancy below W.L. 4										=	1.86 ft.

The centre of buoyancy may be determined from the displacement curve by calculating the area enclosed within the figure formed by the vertical line representing the draught of 5 ft., the horizontal line equal to the tons displacement at this draught and the curve itself. This area divided by the length of the horizontal line referred to, will give the depth of C.B. below L.W.L. In the present example we have: area = 138.6 sq. feet, and length of horizontal line (displacement in tons) = 73.82, and

$$\frac{138.6}{73.82} = 1.87 \text{ feet,}$$

distance of C.B. below L.W.L.

A like result may also be obtained by taking the sum of the products of each water line, and dividing them by the sum of Simpson's multipliers. The mean half-breadths of water lines so obtained may be then used to draw a *mean section* of the

vessel on stout paper, which on being cut out with a knife and swung in two positions, the points being intersected afterwards, will give the centre of gravity (buoyancy) very accurately.

Various approximate methods are in vogue for finding this centre, some of which are fairly accurate.

$$\text{(1) Approx. C.B. above base} = d\left(\frac{5a-2\delta}{6a}\right).$$

$$\text{(2) Approx. C.B. below L.W.L.} = \frac{1}{3}\left(\frac{d}{2}+\frac{V}{A}\right),$$

where A is the area of load-water plane.

This centre, as will be explained, has an important bearing on the stability of the ship.

Centre of Buoyancy Longitudinally (L.C.B.).

Ordinates.	Areas.	Multipliers.	Functions.	Intervals.	Moments.	After Moment.
0	.24	$\frac{1}{4}$	.06	5	.30	
$\frac{1}{2}$	1.91	1	1.91	$4\frac{1}{2}$	8.59	
1	6.17	$\frac{3}{4}$	4.63	4	18.52	
2	14.18	2	28.36	3	85.08	
3	21.40	1	21.40	2	42.80	
4	25.71	2	51.42	1	51.42	206.71
5	26.89	1	26.89	0	. . .	**Forward Moment.**
6	24.14	2	48.28	1	48.28	
7	18.86	1	18.86	2	37.72	
8	12.65	2	25.30	3	75.90	
9	5.92	$\frac{3}{4}$	4.44	4	17.76	
$9\frac{1}{2}$	2.83	1	2.83	$4\frac{1}{2}$	12.74	
10	.08	$\frac{1}{4}$	.02	5	.10	192.50
Function of displacement . . = 234.40					Preponderating moment abaft, Ordinate 5.	= 14.21

$$\frac{14.21}{234.4} = .06 \text{ Interval C.B. abaft 5.}$$

Common Interval = 10 ft. × .06 = 0.6 ft. C.B. abaft No. 5.

The locus of the centre of buoyancy in a fore-and-aft direction is of course the centre of gravity of the displacement, and is the

pivotal point or fulcrum for the moments of all weights placed forward or aft of this position. It will be obvious, therefore, that its location is of great value in determining the trim of the vessel, and the various alterations thereof due to rearrangements of weights on board. Its position is calculated by taking the areas of the sections and putting them through the multipliers; these functions of areas are in turn multiplied by the number of intervals, (each one is forward or aft of the mid-ordinate,) and the difference between these forward and after moments divided by the sum of the area functions. The quotient resulting is the number (or fraction) of intervals that the centre of buoyancy is forward or aft of the $\frac{1}{2}$ length according as the moment preponderates forward or aft respectively.

This centre should be calculated for various draughts, as of course it changes with different draughts and alterations of trim, owing to the changing relationship between the fineness of fore and after bodies at different immersions and trims.

Transverse Metacentre (M.C.)

The position of this element is, in conjunction with the centre of gravity, the most vital in the design of the ship. As its name implies, it is the centre or point beyond which the centre of gravity of the ship may not be raised without producing unstable equilibrium in the upright position, or, otherwise stated, if the ship be inclined transversely to a small angle of heel, the centre of buoyancy which originally was on the centre line will move outboard to a new position; but, as it acts vertically upward, it must somewhere intersect the centre line. This point of intersection is known as the metacentre. One of the factors in the determination of its location above the centre of buoyancy has already been calculated, viz: the volume of displacement V; the other, the moment of inertia of the water plane about the centre line of ship, we shall proceed to compute. The height M above the C.B. or B.M. is found by: —

$$\frac{\text{Moment of Inertia of Water Plane}}{\text{Volume of Displacement}}, \text{ or, } \frac{I}{V} = \text{B.M.}$$

The moment of inertia of the water plane is a geometrical measure of the resistance of that plane to "upsetting," or when taken about the centre line, as in the case of calculating for transverse metacentre, to "careening." So that the greater the waterline breadth the higher will be its value; for we must imagine the water plane as being divided into a great number of small areas, and each of these multiplied by the square of its distance from the

centre line of ship, when the sum of these products will equal th moment of inertia of half the water plane, about the middle lin of vessel as an axis. As both sides of the water plane are sym metrical, the total I will be this result multiplied by 2. Applyin this principle to W.L. 4 in the example with which we are con cerned, we get the following tabular arrangement: —

Moment of Inertia of Water Plane (I).

Ordinates.	Half-Breadths of W.L. 4.	Cubes of Half-Breadths.	Simpson's Multipliers.	Products.
0	.04	. . .	¼	. . .
½	1.41	2.74	1	2.74
1	3.10	29.79	¾	22.34
2	4.81	111.28	2	222.56
3	5.56	171.88	1	171.88
4	5.96	211.71	2	423.42
5	6.00	216.00	1	216.00
6	5.58	173.74	2	347.48
7	4.87	115.50	1	115.50
8	3.57	45.50	2	91.00
9	1.90	6.86	¾	5.14
9½	.97	. . .	1	. . .
10	.03	. . .	¼	. . .

	1,618.06
⅔ C.I.	$6.\dot{6}$
	10,787.07
	⅔
Moment of Inertia	= 7,191.38
Volume of Displacement, V	= 2,583.70

$$\text{B.M.} = \frac{I}{V} = \frac{7191.38}{2583.7} = 2.77 \text{ ft.}$$

The calculation for Moment of Inertia and Transverse Met centre above C.B. may be more easily remembered if we treat t cubes of water line half-breadths as the ordinates of a curve tw thirds the area of which will equal I, and this, in turn, divided l V will give B.M.

However, when we know a, or the coefficient of water line, v may arrive very accurately at the moment of inertia of the wat

plane, and consequently at the *B.M.* without the labor of the foregoing calculation by multiplying the Length by the Breadth^3 by a coefficient, which coefficient will be determined by a and selected from the table given on page 48. By referring to this table, we find for a (value .694) that the coefficient "i" (inertia coefficient) is equal to .0414, whence we get $I = L \times B^3 \times i = 100 \times 12^3 \times .0414 = 7154$ moment of inertia, which is sufficiently close for all purposes, and:—

$$\text{B.M.} = \frac{7154}{2583.7} = 2.76.$$

By transposing and taking the calculated I, we find

$$i = \frac{7191}{100 \times 12^3} = .0416.$$

Longitudinal Metacentre (L.M.C.)

From the definition given for the transverse metacentre it will be seen that if the ship be inclined longitudinally, instead of, as in the former case, transversely, through a small angle that the point in which the vertical through the altered C.B. intersects the original one will also give a metacentre known as the longitudinal, or L.M.C. Its principal use and value are in the determination of the moment to alter trim and the pitching qualities of the vessel, or longitudinal stability. It will be obvious that the moment of inertia of the water plane must be taken through an axis at right angles to the previous case, viz., at right angles to the centre line through the centre of gravity of water plane, which will be where the original and new water planes cross one another in a longitudinal view.

$$\text{L.M.C. above C.B.} = \frac{I_1 \text{ of Water Plane about its C.G.}}{\text{Volume of Displacement}}.$$

Therefore, to calculate the $M\,I_1$, we must figure the moment of inertia with, say, ordinate 5 (or any other one) as an axis when the moment about a parallel axis through the centre of gravity plus the product of the area of water plane multiplied by the square of the distance between the two axes will equal the moment about ordinate 5.

The moment of inertia about the midship ordinate we shall call I, and the distance of the centre of gravity from this station $= x$. The moment of inertia about the centre of gravity of plane $= I_1$. We then have $I = I_1 + Ax^2$, or $I_1 = I - Ax^2$. A clearer conception of this will be obtained from the tabulated arrangement.

Longitudinal Metacentre.

(Common Interval 10 Feet.)

Ordinates.	Half Breadths. W.L. 4.	Simpson's Multipliers.	Products for Area.	Levers.	Products for Moments.	Multipliers for M. I.	Products for Moments of Inertia.
0	.04	$\frac{1}{4}$	.01	5	.05	5	.25
$\frac{1}{2}$	1.41	1	1.41	$4\frac{1}{2}$	6.34	$4\frac{1}{2}$	28.53
1	3.10	$\frac{3}{4}$	2.32	4	9.28	4	37.12
2	4.81	2	9.62	3	28.86	3	86.58
3	5.56	1	5.56	2	11.12	2	22.24
4	5 96	2	11.92	1	11.92	1	11.92
5	6.00	1	6.00	0	67.57	0	. . .
6	5.58	2	11.16	1	11.16	1	11.16
7	4.87	1	4.87	2	9.74	2	19.48
8	3.57	2	7.14	3	21.42	3	64.26
9	1.90	$\frac{3}{4}$	1.42	4	5.68	4	22.72
$9\frac{1}{2}$	.97	1	.97	$4\frac{1}{2}$	4.36	$4\frac{1}{2}$	19.62
10	.03	$\frac{1}{4}$	.01	5	.05	5	.25
. . .	. . .	. . .	62.41	. . .	52.41	. . .	324.13

Area of water plane $= 62.41 \times (\frac{2}{3} \times 10) \times 2.$
$= 832.14$ square feet.

Distance of centre of flotation abaft ordinate 5

$$= \frac{(67.57 - 52.41)\ 10}{62.41} = 2.42 \text{ feet.}$$

Moment of inertia of water plane about ordinate 5

$$= 324.13 \times (\tfrac{2}{3} \times 10) \times 10^2 \times 2 = 432{,}172 = I.$$

Moment of inertia of water plane about axis through its centre of flotation.

$$= 432{,}172 - (832.14 \times 2.42^2) = 427{,}304 = I_1.$$

Longitudinal metacentre above C.B.

$$\frac{I}{V} = \frac{427{,}304}{2583.7} = 165 \text{ feet} = \text{Longitudinal B.M.}$$

An excellent approximate formula for the longitudinal B.M. is given by J. A. Normand in the 1882 transactions of the I.N.A. Taking the symbols we have been using :—

$$\text{L.B.M.} = .0735\,\frac{A^2 \times I}{B \times V}.$$

Applying this formula to the vessel with which we are dealing, we find :

$$\text{L.B.M.} = .0735\,\frac{832.14^2 \times 100}{12 \times 2583.7} = 164.12 \text{ feet.}$$

which is a very close approximation to the calculated result of 165 feet.

We may also use the approximate formula which we applied in the case of the transverse B.M. altered to suit the new axis with a modified coefficient, as :—

$$\text{L.B.M.} = L^3 \times B \times i_1.$$

Moment to Change Trim (M_1).

As the centre of gravity of the displacement (or centre of buoyoncy), either in the vertical or the longitudinal direction may be an entirely different locus from the ship's centre of gravity, it is obvious that unless the moment of the weights of the ship and engines, with all equipment weights, balances about the centre of buoyancy we shall have a preponderating moment deflecting the head or stern, as the moment is forward or aft of the C.B., respectively, until the vessel shall have reached a trim in which the pivotal point or C.B. is in the same vertical line as the completed ship's centre of gravity. To determine the moment necessary to produce a change of trim (M_1) in a given ship, it is necessary to know the vertical position of the centre of gravity of the vessel and the height of the longitudinal metacentre (L.M.C.). The former may be calculated in detail or preferably proportioned from a similar type ship whose centre of gravity has been found by experiment; although great accuracy in the location of this centre in calculating the moment is not as important as in the case of G.M. for initial stability, as small variations in its position can only affect the final result infinitesimally. To investigate the moment affecting the trim, let us move a weight P already on board of the 100-foot steamer whose calculations are being figured.

D = Weight of ship including weight P = 73.82 tons.
BM = 165 feet. P = 5 Tons.
GM = 160 feet. l = 50 feet (distance moved).
L = 100 feet (length of vessel).

In the figure we have the centre of gravity G to G_1, and centre of buoyancy from B to B_1, due to the shifting of the wei P forward for a distance represented by l, giving a moment

$$D \times GG_1 = P \times l, \quad \text{and} \quad GG_1 = \frac{P \times l}{D}.$$

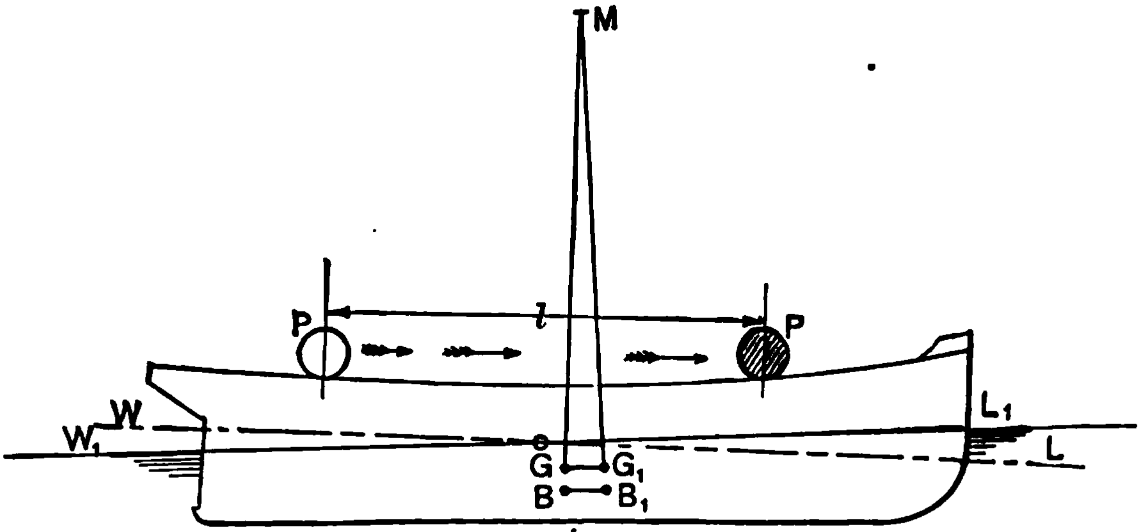


FIG. 6.

The new water line is at W_1L_1 and B_1G_1 are in the same ve cal and at right angles to it, and the point of intersection of original and new water line at "O" equal to the centre of gra (flotation) of water plane, therefore the triangles GMG_1, WO and LOL_1, are of equal angle, so that

$$\frac{GG_1}{GM} = \frac{WW_1}{WO} = \frac{LL_1}{LO} = \frac{WW_1 + LL_1}{WO + LO}.$$

But $WW_1 + LL_1$ is the change of trim, and $WO + LO$ is the ler of the vessel $= L$, then

$$\frac{\text{change of trim}}{L} = \frac{WW_1 + LL_1}{WO + LO};$$

but we have seen that

$$GG_1 = \frac{GM \times \text{change of trim}}{L} = \frac{P \times l}{D}.$$

Then $$\text{Change of trim} = \frac{P \times l \times L}{D \times GM} \text{ feet.}$$

Substituting the values, we get: —

$$\frac{P \times l \times L}{D \times GM} = \frac{5 \times 50' \times 100'}{73.82 \times 160} = 2.116 \text{ feet} = 24\tfrac{1}{8} \text{ inches.}$$

Calling this change of trim 24 inches, and assuming that the p of intersection "O" is at the centre of the length, we should l

the stem *immersed* 12 inches and the stern raised 12 inches from the original water line, the sum of these figures equalling the total change.

Moment to Alter Trim One Inch (M'').

From the foregoing it will be seen that the total change of trim being known for a given moment, inversely we may get the amount necessary to alter the trim for one inch only, this being a convenient unit with which to calculate changes of trim when a complexity of varying conditions are being dealt with. As we have seen $P \times l = M_1$ the moment to change trim, and

$$\text{Change of trim} = \frac{M_1 \times L}{D \times GM} \text{ feet};$$

therefore,

$$\tfrac{1}{12} \text{ foot or one inch} = \frac{D \times GM}{12 \times L} = M''.$$

Substituting values we have: —

$$M'' = \frac{73.82 \times 160'}{12 \times 100} = 9.84 \text{ foot-tons.}$$

In designing preliminary arrangements of vessels, it is necessary that we should know fairly accurately the moment which it will take to alter the trim one inch (M'') to enable us to arrange the principal weights in the ship, and the varying effects on the trim consequent on their alteration in position or removal. For this purpose a close approximation to this moment (M'') is desirable and may be calculated from Normand's formula as follows:

$$M'' = \frac{A^2}{B}.0001725, \quad \text{or} \quad \frac{\mathfrak{W}''^2 \times 30.9}{B}.$$

Where A^2 = the square of the water plane area, and B = the greatest breadth of water plane. Applying this approximate formula to the foregoing example, we have: —

$$M'' = \frac{832.14^2}{12} \times .0001725 = 9.95 \text{ foot-tons,}$$

as against 9.84 foot-tons found by actual calculations, a difference too insignificant to affect noticeably the change in trim.

This moment is useful to have for various draughts, and consequently should be calculated for light and load conditions, and for one or two intermediate spots and a curve of M'' run on the usual sheet of "Curves of Elements."

Alteration in Trim through Shipping a Small Weight.

If it be required to place a weight on board but to retain the same trim, *i.e.*, to float at a draught parallel to the original one, the weight added must be placed vertically above the centre of gravity of the water plane. Should, however, the weight be required in a definite position, then the altered trim will be as under:—

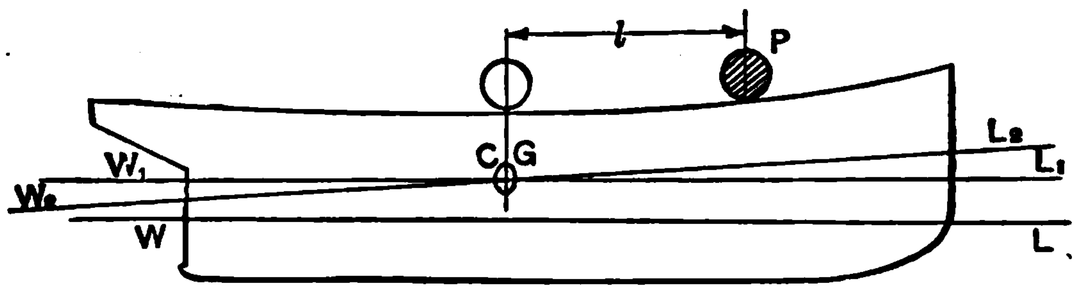


FIG. 7.

Instead of dealing with the weight at P let us assume firstly that it is placed on board immediately over the C.G. of water plane, when we shall find the parallel immersion to be a layer equal to the distance between WL and W_1L_1 whose depth is $\frac{P}{\mathfrak{T}''}$

Let the weight be now moved to its definite position at a distance l forward of C.G., then

$$\text{Change of trim} = \frac{P \times l \times L}{(D + P)\ GM} = C.$$

GM of course will be the amended height due to altered condition after the addition of P. Then:—

$$\text{Draught forward} = \frac{C}{2} + \frac{P}{\mathfrak{T}''}.$$

$$\text{Draught aft} \quad = \frac{C}{2} - \frac{P}{\mathfrak{T}''}.$$

Of course we assume that the alteration is of like amount forward as aft. This is only partly correct, but where small weights are dealt with is sufficiently so for most purposes. Generally the ship is fuller aft on and near the load line than forward, and probably a water plane midway between base and L.W.L. would have its centre of flotation at the half length, so that a curve drawn through the centres of gravity of the water planes would incline aft, and as we have assumed the weight as being placed on board over the C.G. of the original water plane, it is obvious that the

new line will have its centre of flotation somewhat further aft, and consequently the tangent of the angle W_1OW_2 will be less than that of L_1OL_2. With large weights and differences in the two draughts, the disparity would become sufficiently great to require reckoning, in which event the assumed parallel line in the preceding case would give the water line from which to determine the centre of flotation. Thereafter on finding the change of trim, which we shall call 10 inches, the amount of immersion of stem and emersion of stern post would be in proportion to the distance from O to stem and O to post relatively to the length of water line. If we call "O" to stem 60 feet and "O" to post 40 feet, the water line length being 100 feet, we have: —

$$\left.\begin{array}{ll}\text{Immersion forward} & \frac{60}{100} \times 10'' = 6 \text{ inches} \\ \text{Emersion aft} & \frac{40}{100} \times 10 \;\; = 4 \text{ inches}\end{array}\right\} \begin{array}{l}\text{Total change} \\ \text{10 inches.}\end{array}$$

TCHIBYSCHEFF'S RULE.

In the preceding pages we have treated with the common application of Simpson's first rule to ship calculations. Another method, equally, if not more simple, which is slowly gaining favor with naval architects is that devised by the Russian Tchibyscheff. This rule has the great advantage of employing fewer figures in its application; more especially is this the case in dealing with stability calculations, and its usefulness in this respect is seen in the tabular arrangement given here. It has the additional advantage of employing a much less number of ordinates to obtain a slightly more accurate result and the use of a more simple arithmetical operation in its working out, viz. addition. As the ordinates, however, are not equidistant, it has the disadvantage of being inconvenient when used in conjunction with designing, and for this reason its use is advocated for the *finished* displacement sheet and calculations for G.Z.

The rule is based on a similar assumption to Simpson's, but the ordinates are spaced so that addition mostly is employed to find the area. The number of ordinates which it is proposed to use having been selected, the subjoined Table gives the fractions of the half length of base at which they must be spaced, starting always from the half length. The ordinates are then measured off and summed, the addition being divided by the number of the ordinates, giving a mean ordinate, which multiplied by the length of base produces the area: —

$$\frac{\text{Sum of ordinates}}{\text{No. of ordinates}} \times \text{Length of base} = \text{Area.}$$

Tchibyscheff's Ordinate Table.

Number of Ordinates.	Distance of Ordinates from Middle of Base,)(, in Fractions of Half the Base Length.
2	.5773
3	)(, .7071
4	.1876, .7947
5	)(, .3745, .8325
6	.2666, .4225, .8662
7	)(, .3239, .5297, .8839
9	)(, .1679, .5288, .6010, .9116
10	.0838, .3127, .5000, .6873, .9162

The employment of this rule to find the volume of displacement and the other elements usually tabulated on the displacement sheet is shown on the attached Tables. The number of stations used is ten, as in the case of Simpson's rule, but for clearness the after body five are indicated by Roman numerals, and the fore body ones in Arabic. The displacement length is 600 feet, therefore by taking the fractions given in the preceding table for ten ordinates and multiplying them by 300, we shall obtain the distance of the displacement sections apart. These distances from the half-length and the sections are here given as used for the Table, but it will be observed that the water lines are spaced to suit Simpson's first rule for the vertical sections as no advantage would be gained by the use of Tchibyscheff in this direction, owing to the fewer number of water lines generally necessary. The various operations in the Table will be clearly understood from the headlines of the respective columns.

As already pointed out, the great value of this rule is in the calculations to obtain cross curves of stability, specimen tables of which are also given. The fewness of the sections necessary, and the fact that the integrator saves the calculator the tedium of adding up, tells greatly in favor of the adoption of this rule for these calculations both as a time saver and an eliminator of the chances of error.

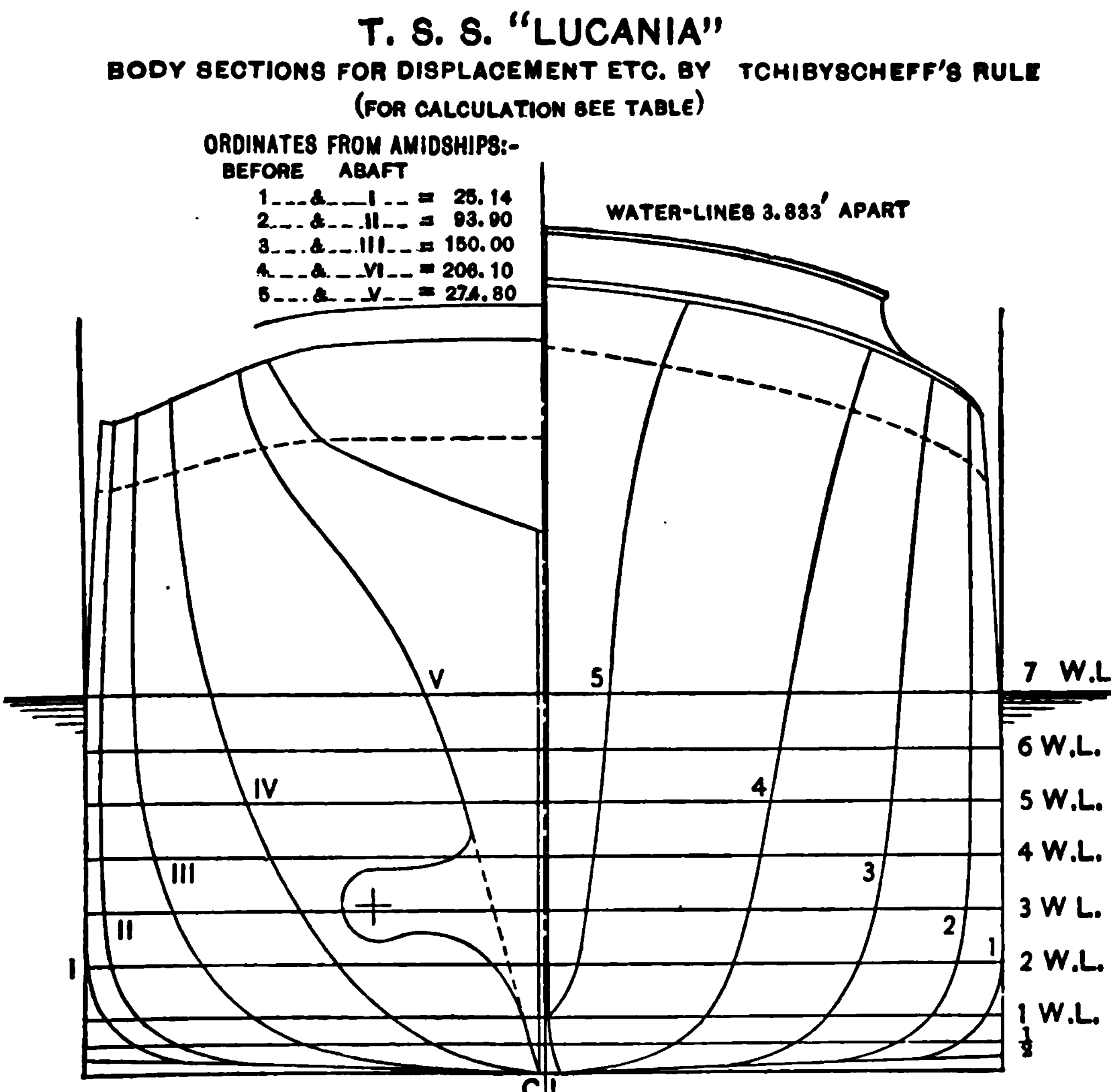

T. S. S. "LUCANIA"
BODY SECTIONS FOR DISPLACEMENT ETC. BY TCHIBYSCHEFF'S RULE
(FOR CALCULATION SEE TABLE)
ORDINATES FROM AMIDSHIPS:-
BEFORE ABAFT
1 & I = 25.14
2 & II = 93.90
3 & III = 150.00
4 & VI = 206.10
5 & V = 274.80
WATER-LINES 3.833' APART
7 W.L.
6 W.L.
5 W.L.
4 W.L.
3 W L.
2 W.L.
1 W.L.
½
C.L.

FIG. 8.

Displacement Sheet by

Stations.	Water Lines.					
		½	1	2	3	. 4
	¼	1	¾	2	1	2
I	.60	29.35	31.20	32.30	32.50	32.50
	.15	29.35	23.40	64.60	32.50	65.00
1	. .60	29.35	31.20	32.25	32.50	32.50
	.15	29.35	23.40	64.50	32.50	65.00
II	.60	26.25	28.84	31.00	31.30	31.40
	.15	26.25	21.63	62.00	31.30	62.80
2	.60	25.00	27.35	29.25	30.00	30.20
	.15	25.00	20.51	58.50	30.00	60.40
III	.60	16.90	20.85	24.60	26.55	27.85
	.15	16.90	15.64	49.20	26.55	55.70
3	.60	17.50	19.85	22.15	23.35	24.15
	.15	17.50	14.89	44.30	23.35	48.30
IV	.60	7.80	11.10	14.80	17.50	19.40
	.15	7.80	8.33	29.60	17.50	38.80
4	.60	7.00	11.15	13.20	14.45	15.35
	.15	7.00	8.36	26.40	14.45	30.70
V	.60	1.00	1.50	2.55	3.55	4.65
	.15	1.00	1.13	5.10	3.55	9.30
5	.00	.00	.15	2.20	3.10	3.65
	.00	.00	.11	4.40	3.10	7.30
Sum of Ordinates	5.40	160.15	183.19	204.30	214.80	221.65
Functions	1.35	160.15	137.38	408.60	214.80	443.30
Levers	7.00	6.50	6	5	4	3
Moments	9.45	1,040.98	824.28	2,043.00	859.20	1,329.90
						Multipliers for Areas
Areas of Water Lines	648.00	19,218.00	21,983.00	24,516.00	25,776.00	26,598.00
						Divisor for Tons
Tons per Inch	1.543	45.76	52.36	58.371	61.37	63.29
$V=$	Displacement in cubic feet $\frac{2 \times 600 \times 2 \times 3.833}{3 \times 10\,*} \times$					
$D=$	Displacement in tons . . $\frac{\dagger 2 \times 600 \times 2 \times 3.833}{\dagger 3 \times 10 \times 35} \times$					

$\Delta =$ Distance of Ordinates.

* *10 = number of stations.* † 3 = Simpsons' multiplier.

Tchibyscheff's Rule.

			Vertical Sections.			
5	6	7	Functions.	Differences.	Levers.	Moments.
1	2	$\frac{1}{2}$				
32.50	32.40	32.35				
32.50	64.80	16.18	328.48			
32.50	32.40	32.30				
32.50	64.80	16.15	328.35	.13	.0838	.109
31.45	31.50	31.45				
31.45	63.00	15.73	314.31			
30.25	30.35	30.40				
30.25	60.70	15.20	300.71	13.60	.313	4.259
28.55	29.10	29.25				
28.55	58.20	14.63	265.52			
24.65	25.10	25.40				
24.65	50.20	12.70	236.04	29.48	.500	14.740
21.00	22.45	23.70				
21.00	44.90	11.85	179.93			
16.10	16.90	17.45				
16 10	33.80	8.73	145.69	34.24	.687	23.523
5.75	6.90	8.25				
5.75	13.80	4.13	43.91			
4.10	4.50	4.80				
4.10	9.00	2.40	30.41	13.50	.916	12.367
226.85	231.60	235.35	$= \Sigma_1$	Distance of Water Lines $= 3.833'$		54.998
226.85	463.20	117.68	2,173.31			
2	1	0				
453.70	463.20	0	7,023.71			

of Water Lines: $\frac{600}{10} \times 2$.

27,222.00	27,792.00	28,242.00

per Inch: 420.

64.814	66.171	67.243

2,173.31 = 666,445.25

2,173.31 = 19,041.29

Centre of Buoyancy.

$$\frac{7{,}023.71 \times 3.833}{2{,}173.31} = 12.39' \left\{ \begin{array}{l} \text{below} \\ \text{W.L. 7} \end{array} \right.$$

$$\frac{54.998 \times 600}{2{,}173.31 \times 2} = 7.59' \text{ abaft } ☊$$

$$\frac{\Delta^2}{24} \times (3 \times 0_1 + 10 \times 0_2 - 0_3) = \text{Moments.}$$

$\Sigma_1 \times \frac{600}{10} \times 2 =$ Area of Water Lines.

Center of Buoyancy and

Water Lines.	Sums of Ordinates.	Mults.	Products.	Levers.	Moments.	Formula.	C.B. above Keel.
Keel	5.40	$\frac{1}{4}$	1.35	0			
W.L. $\frac{1}{2}$	160.15	1	160.15	$\frac{1}{2}$	80.07		
W.L. 1	183.19	$\frac{1}{4}$	45.80	1	45.80		
			207.31		125.88	$3.833 \times \frac{125.87}{207.31} =$	2.328
W.L. 1	183.19	$\frac{1}{2}$	91.60	1	91.60		
W.L. 2	204.30	2	408.60	2	817.20		
W.L. 3	214.80	$\frac{1}{2}$	107.40	3	322.20		
			814.90		1,356.87	$3.833 \times \frac{1356.87}{814.90} =$	6.383
W.L. 3	214.80	$\frac{1}{2}$	107.40	3	322.20		
W.L. 4	221.65	2	443.30	4	1,773.20		
W.L. 5	226.85	$\frac{1}{2}$	113.43	5	567.15		
			1,479.03		4,019.46	$3.833 \times \frac{4019.46}{1479.07} =$	10.420
W.L. 5	226.85	$\frac{1}{2}$	113.43	5	567.15		
W.L. 6	231.60	2	463.20	6	2,779.20		
W.L. 7	235.35	$\frac{1}{2}$	117.68	7	823.76		
			2,173.34		8,189.57	$3.833 \times \frac{8189.57}{2173.38} =$	14.450

Displacement in

Keel to W.L. 1: $\frac{2 \times 600 \times 2 \times 3.833}{3 \times 10} \times 207.31 =$

W.L. 1 to W.L. 2: $\frac{2 \times 600 \times 3.833}{10 \times 12} \times 2{,}335.55 =$

Keel to W.L. 3: $\frac{2 \times 600 \times 2 \times 3.833}{3 \times 10} \times 814.90 =$

W.L. 1 to W.L. 4: $\frac{3 \times 600 \times 2 \times 3\ 833}{3 \times 10} \times 1{,}662.14 =$

Keel to W.L. 5: $\frac{2 \times 600 \times 2 \times 3.833}{3 \times 10} \times 1{,}479.03 =$

W.L. 4 to W.L. 6: $\frac{600 \times 2 \times 3.833}{3 \times 10} \times 1{,}360.65 =$

Keel to W.L. 7: $\frac{2 \times 600 \times 2 \times 3.833}{3 \times 10} \times 2{,}173.34 =$

$\frac{\Delta}{12} \times (5 \times 0_1 + 8 \times 0_2 - 0_3) =$ Area by $\frac{5}{8}$ rule. $\frac{\Delta^2}{24} \times (3 \times 0_1 + 10 \times 0_2 - 0_3 =$ Moments.

Displacement, by Tchibyscheff's Rule.

Water Lines.	Sums of Ordinates.	Mults.	Products.	Levers.	Moments.	Formula.	C.B. above Keel.
1	183.19	5	915.95	3	549.57	$3.833 \times \dfrac{2377.77}{2335.55} =$	1.95
2	204.30	8	1634.40	10	2043.00		3.833
3	214.80	1	−214.80	1	−214.80	C.B. of W.L.−W.L.$_2$ =	5.783
			2335.55		2377.77	$\dfrac{5.783 \times 89521.63 + 2.328 \times 63574.52}{89521.63 + 63574.52} =$	4.33
1	183.19	1	183.25	1	183.19	$3.833 \times \dfrac{4228.79}{1662.14} =$	9.76
2	204.30	3	612.90	2	1225.80		
3	214.80	3	644.40	3	1933.20	$\dfrac{9.76 \times 286577.44 + 2.328 \times 63574.52}{286577.44 + 63574.52} =$	8.40
4	221.65	1	221.65	4	886.60		
			1662.14		4228.79		
4	221.65	1	221.65	4	886.60	$3.833 \times \dfrac{6813.40}{1360.65} =$	19.20
5	226.85	4	907.40	5	4537.20		
6	231.60	1	231.60	6	1389.60		
			1360.65		6813.40	$\dfrac{19.2 \times 208614.86 + 8.4 \times 350151.96}{208614.86 + 350151.96} =$	12.45

Cubic Feet = V.

	Cubic Feet.		C.B. Above Keel.
63,574.52	63,574.52	= Keel to W.L. 1.	2.328
89,521.63	153,096.15	= Keel to W.L. 2.	4.33
. . .	249,912.80	= Keel to W.L. 3.	6.383
286,577.44	350,151.96	= Keel to W.L. 4.	8.40
. . .	453,558.21	= Keel to W.L. 5.	10.420
208,614.86	558,766.82	= Keel to W.L. 6.	12.45
. . .	666,445.24	= Keel to W.L. 7.	14.45

$$\text{Lever} = \frac{\Delta^2}{24} \times \frac{(3 \times O_1 + 10 \times O_2 - O_3)}{(5 \times O_1 + 8 \times O_2 - O_3)} = \frac{\Delta}{2} \times \frac{(3 \times O_1 + 10 \times O_2 - O_3)}{(5 \times O_1 + 8 \times O_2 - O_3)}.$$

Longitudinal Metacenters and Centers

Stations.	I	1	II	2	III	3	IV	4	V	5
	Δ	Σ	Δ	Σ	Δ	Σ	Δ	Σ	Δ	Σ
W.L. 7 .	32.35	32.30	31.45	30.40	29.25	26.40	23.70	17.45	8.25	4.80
Δ respective Σ	. . .	64.65	1.05	61.85	3.85	54.65	6.25	41.15	3.45	13.05
Lever respective to Lever²	.084	.007	.313	.098	.50	.25	.687	.472	.916	[illegible]
Moments .	. . .	. . .	.329	. . .	1.925	. . .	4.294	. . .	3.160	. . .
Moments for I	. . .	.453	. .	6.061	. . .	13.660	. . .	19.423	. . .	10.962
W.L. 6 . .	32.40	32.40	31.50	30.35	29.10	25.10	22.45	16.90	6.90	4.50
Δ respective Σ	. . .	64.80	1.15	61.85	4.00	54.20	5.55	39.35	2.40	11.40
Lever respective to Lever²	[illegible]	.007	.313	.098	.50	.25	.687	.472	.916	.840
Moments .	. . .	. . .	.340	. . .	2.00	. . .	3.813	. . .	2.198	. . .
Moments for I	. . .	.454	. . .	6.061	. . .	13.55	. . .	18.573	. . .	9.576
W.L. 5 . .	32.50	32.50	31.45	30.25	28.55	24.65	21.00	16.10	5.75	4.10
Δ respective Σ	. . .	. . .	1.20	61.70	3.90	53.20	4.90	37.10	1.65	9.85
Lever respective to Lever²	.084	.007	.313	.098	.50	.25	.687	.472	.916	.840
Moments .	. . .	. . .	.376	. . .	1.95	. . .	3.366	. . .	1.511	. . .
Moments for I	. . .	. . .	. . .	6.047	. . .	13.30	. . .	17.510	. . .	8.274
W.L. 4 . .	32.50	32.50	31.40	30.20	27.85	24.15	19.40	15.35	4.65	3.65
Δ respective Σ	. . .	. . .	1.20	61.60	3.70	52.00	4.05	34.75	1.00	8.30
Lever respective to Lever²	.084	.007	.313	.098	.50	.25	.687	.472	.916	.840
Moments .	. . .	. . .	.376	. . .	1.850	. . .	2.782	. . .	.916	. . .
Moments for I	. . .	. . .	. . .	6.037	. . .	14.00	. . .	16.400	. . .	6.972

Δ = Difference. **Σ = Sum.**

Σ_s = Sum of Moments (Sums × lever²) for I.

of Flotation, by Tchibyscheff's Rule.

Σ of Moments. Σ_2	Σ of Moments. Σ_3	Center aft ⚹ $\Sigma_2 \times \frac{L}{2} \times \frac{1}{\Sigma_1}$	Center of Flotation, etc.	I (Axis = ½L between P.P.)	Deduction Area W L. $\times a^2$.	V / I_1	$\frac{I_1}{V}$
. .	. . .	. . . .	. . .	$\frac{L \times \left(\frac{L}{2}\right)^2}{10} \times$	. . . .	. . .	Longitudinal
. .	. . .	. . . .	. . .	$2 \times \Sigma_3$	26,242×12.09²	666,445	B.M
. .	. . .	. . . .	. . .	$=10,800,000\ \Sigma_3$	. . . .	. . .	in Ft.
9.706	. . .	$9.706 \times \frac{300}{235.35}$	12.09	. . . .	. . . .	. . .	. . .
. .	50.559	. . . .	. . .	546,900,000	4,128,000	542,772,000	812.93
. .	. . .	. . . .	. . .	. . . .	. . . .	. . .	. . .
. .	. . .	. . . .	. . .	. . . .	27,792×10.813²	558,767	. . .
. .	. . .	. . . .	. . .	. . . .	. . . .	. . .	. .
8.351	. . .	$8.351 \times \frac{300}{231.60}$	10.813	. . . .	. . . .	. . .	. . .
. .	48.214	. . . .	. . .	520,711,200	3,249,440	517,461,760	926.07
. .	. . .	. . .	. . .	. . . .	. . . .	. . .	. . .
. .	. . .	. . . .	. . .	. . . .	27,222× 9.526	453,558	. . .
. .	. . .	. . . .	. . .	. . . .	. . . .	. . .	. . .
7.203	. . .	$7.203 \times \frac{300}{226.85}$	9.526	. . . .	. . . .	. . .	. . .
. .	45.131	. . . .	. . .	487,414,800	2,469,715	484,945,085	1069.2
. .	. . .	. . . .	. . .	. . . .	. . . .	. . .	. . .
. .	. . .	. . . .	. . .	. . . .	26,596× 8.018²	350,152	. . .
. .	. . .	. . . .	. . .	. . . .	. . . .	. . .	. . .
5.924	. . .	$5.924 \times \frac{300}{221.65}$	8.018	. . . .	. . . .	. . .	. . .
. .	43.409	. . . .	. . .	468,817,200	1,709,832	467,107,368	1334.0

Σ_1 = Sum of Ordinates on Displacement Table.
Σ_3 = Sum of Moments (differences × lever) for Centers of Flotation.

Transverse Metacenters, by Tchibyscheff's Rule.

Station.	I	1	II	2	III	3	IV	4	V	5	Σ of Cubes.	$\frac{2}{3}\times\frac{L}{10}\times\Sigma=I$ $=40\Sigma=I$.	*V	$\frac{I}{V}=BM$
W.L. 7 .	32.35	32.30	31.45	30.40	29.25	25.40	23.70	17,45	8.25	4.80	. . .	. . .	. . .	. . .
Cubes .	33,850	33,700	31,150	28,094	25,200	16,390	13,310	5,313	561.50	110.60	186,691	7,467.64	666,445	11.12
W.L. 6 .	32.40	32.40	31.50	30.35	29.10	25.10	22.45	16.90	6.90	4.50	. . .	. . .	. . .	. . .
Cubes .	34,012	34,012	31,256	27,961	24,642	15,813	11,315	4,826	329.	91.	184,257	7,370,280	558,767	13.192
W.L. 5 .	32.50	32.50	31.45	30.25	28.55	24.65	21.00	16.10	5.75	4.10	. . .	. . .	. . .	. . .
Cubes .	34,328	34,328	31,150	27,680	23,270	14,980	9,261	4,173	190.11	68.92	179,429	7,177,160	453,558	15.824
W.L. 4 .	32.50	32.50	31.40	30.20	27.85	24.15	19.40	15.35	4.65	3.65	. . .	. . .	. . .	. . .
Cubes .	34,328	34,328	30,959	27,544	21,600	14,080	7,301	3,617	100.5	49.	174,811	6,992,440	350,152	19.998
W.L. 3 .	32.50	32.50	31.30	30.00	26.55	23.35	17.50	14.45	3.55	3.10	. . .	. . .	. . .	. . .
Cubes .	34,328	34,328	30,664	27,000	18,710	12,730	5,359	3,018	45.	30.	166,212	6,648,480	249,913	26.603
W.L. 2 .	32.30	32.25	31.00	29.25	24.60	22.15	14.80	13.20	2.55	2.20	. . .	. . .	. . .	. . .
Cubes .	33,698	33,540	29,791	25,020	14,887	10,870	3,242	2,300	17.	11.	153,376	6,135,040	153,096	40.07
W.L. 1 .	31.20	31.20	28.90	27.35	20.85	19.85	11.10	11.15	1.50	.15	. . .	. . .	. . .	. . .
Cubes .	30,371	30,371	24,138	20,460	9,003	7,821	1,368	1,386	3.	. . .	124,981	4,999,240	63,575	78.63

* See Table of Center of Buoyancy and Displacement, pp. 24 to 27.

EXPLANATION OF TABLE, GIVING EFFECT FORM OF WATER LINE ON POSITION OF LONGITUDINAL METACENTER.

Longitudinal and Lateral Stability Compared. — first four lines are exactly the same as those in the other ta and the last eight lines differ only in having length and bre interchanged, so as to give pitching instead of rolling.

On comparing them with the following table, it will be not that, in the algebraic factor, the length and breadth always i change; and that the numerical factor remains unchanged forms (1), (3), and (A), namely, the square or rectangle, circle or ellipse, and the wedge. Of the nine forms selected, t are obviously the only ones in which breadth and length absolutely interchangeable.

With respect to the comparison of the different forms, one another, if we disregard the wave-bow No. (8), the variatio stability follows much the same sequence for longitudinal as lateral stability, but with a somewhat less absolute value. result might be expected *à priori*, because the extreme bre ordinate cuts the outline at right angles in all but the w form (9); while the extreme length ordinate meets the ou more sharply. In forms (2) and (4) this difference is onl the second order; but, as the figures show, it is quite sufficie be of practical importance even in these.

Differ Chiefly in Wave-Bow. — The wave-bow form falls altogether out of its sequence, and its stability is less the wedge form (9) as regards pitching. This is due to sudden falling off of the extreme ordinate length, which m the curve tangentially, instead of normally, as the ext breadth ordinate.

Fine Bow Affects Pitch More than Rolling. — I consider rolling on any given axis, it is easily seen from geom cal considerations, and also from the algebraic form of the gral, that the instantaneous stability depends, firstly, on the le of the transverse axis, and, secondly, on the slowness of the of diminution of that axis, as we pass along that axis of mo Hence sharp bows have less stability for pitching than bluff b while their lateral stability for rolling is not so very different.

Caution in Use of Table. — In the table of lateral stab the element of length only appears as a simple factor; there as regards lateral stability, we may compound the moment

simple addition for a vessel built up in different lengths for the different forms. Thus, the values in lines 1 to 8 of column (2) are simply the means of the corresponding values in columns (1) and (3). We cannot apply this process to the longitudinal stability because here the length element enters as a cubic factor. If we were so to compound the moments of length, what we should really do would be equivalent to screwing together two longitudinal halves of different vessels; in the case before mentioned, screwing half a box to half a tub; not introducing a flat midship length between two semicircular ends.

Explanation of Table Giving Effect of Form of Water Line on Position of Metacenter.

Explanation of Table.—By the preceding table we can at once make an approximate estimate of the value of any proposed form of water line, by selecting that form in the table to which it comes nearest. From this table we gather that the more nearly the water line approaches to a right parallelogram, the more it will contribute to the stability of a ship. No. 9, on the contrary, the straight line wedge form, is the least stable of these water lines, and from the comparison of the successive groups of lines on the table we shall see exactly how this comes about.

Areas on Water Lines.—The first and second lines in the table give the measures simply of the areas of those water lines. From lines 3 and 4 we see that, Fig. 1 being taken as the standard of comparison, Fig. 2 only contains 89 per cent of the rectangular area, and this diminution is effected merely by rounding off the rectangular corners, the length and breadth remaining the same in both. In Fig. 3, when the curvature of the ends extends quite to the middle of the water line, its area is reduced to 69 per cent. In Fig. 6, by forming the water line of parabolic arcs, a favorite form of some builders, the area is reduced to two-thirds of the rectangle. Figs. 7 and 8 are the lines used for a wave stern and a wave bow; from which it appears at once how much more powerful the stern contributed to the stability of a ship than the bow; the stern line being 62 per cent, and the bow line only 50 per cent.

Metacentric Moments.—Lines 5 and 6 are the actual measure of the stability (by its moments) for small inclinations. For example: in the rectangle, the moment is one-twelfth part of the product of the length by the cube of the breadth, or .08 of that product; and as we pass along line 6 we find it gradually diminish, until, in the wedge form, it is only .02, showing that a sharp wedge form has only one-fourth part of the power to carry top weight that the rectangular form has, although its power of buoyancy, or power to carry absolute load, is one-half. This is set out more fully in lines 7 and 8; so that by carefully comparing together line 4 and line 8, the relative values of all those figures for carrying absolute weight and for carrying top weight may be clearly seen.

Metacentric Intervals.—Lines 9 and 10 measure the powers of ships, formed on these water lines only to carry top weight without upsetting.

Effect of Form of Water Line on

From J. Scott Russell,

Length of vessel $= L$.* Breadth on water line

	ALGEBRAIC FACTOR.	(1) Square, or Rectangle. 	(2) Square, with Semi-circular Ends. 	(3) Circular or Elliptic Form. 
1 Area of plane of flotation . .	LB	1	$\frac{4+\pi}{8}$	$\frac{1}{4}\pi$
2 The same, expressed decimally	LB	1.00000	0.89270	0.78540
3 Ratio to same in rectangular form	. .	1	$\frac{4+\pi}{8}$	$\frac{1}{4}\pi$
4 The same, expressed decimally	. .	1.00000	0.89270	0.78540
5 $\int \frac{2}{3} x^3 dy$ †	L^3B	$\frac{1}{12}$	$\frac{16+5\pi}{512}$	$\frac{1}{64}\pi$
6 The same, expressed decimally	L^3B	0.08333	0.06194	0.04909
7 Ratio to same in rectangular form	. .	1	$\frac{48+15\pi}{128}$	$\frac{3}{16}\pi$
8 The same, expressed decimally	. .	1.00000	0.74340	0.58905
9 Height of longitudinal meta-center above center of displacement ‡	$\frac{L^2}{\text{dr.}}$	$\frac{1}{12}$	$\frac{16+5\pi}{16(16+4\pi)}$	$\frac{1}{16}\pi$
10 The same, expressed decimally‡	$\frac{L^2}{\text{dr.}}$	0.08333	0.06937	0.06250
11 Ratio to same in rectangular form ‡	. .	1	$\frac{3(16+5\pi)}{4(16+4\pi)}$	$\frac{3}{4}\pi$
12 The same, expressed decimally‡	. .	1.00000	0.83248	0.75000

* The length L appears simply as a factor. The numerical factor in the table, therefore, remains unchanged if the proportion of L to B be altered, as in passing from the square to the rectangle, or from the circle to the ellipse.

† That is to say, a trochoid twice the length of a cycloid of the same width.

Position of Longitudinal Metacenter.

Nav. Arch., 1865.

amidships = *B*. Draught of water = dr.

NUMERICAL FACTOR FOR					
(4) Cycloid (a Full Wave Stern). 	(5) Circular Segment (Arc of 90°). 	(6) Parabola (Axis Athwartships). 	(7)† Trochoid 1 : 2 (a Wave Stern). 	(8) Curve of Sines (a Wave Entrance). 	(9) Wedge. 
$\frac{3}{4}$	$\frac{\pi-2}{4(\sqrt{2}-1)}$	$\frac{2}{3}$	$\frac{5}{8}$	$\frac{1}{2}$	$\frac{1}{2}$
0.75000	0.68901	0.6667	0.62500	0.50000	0.50000
$\frac{3}{4}$	$\frac{\pi-2}{4(\sqrt{2}-1)}$	$\frac{2}{3}$	$\frac{5}{8}$	$\frac{1}{2}$	$\frac{1}{2}$
0.75000	0.68901	0.66667	0.62500	0.50000	0.50000
$\frac{12\pi^2-35}{192\pi^2}$	$\frac{3\pi-8}{96\sqrt{2}-1}$	$\frac{1}{30}$	$\frac{80\pi^2-373}{1536\pi^2}$	$\frac{\pi^2-6}{24\pi^2}$	$\frac{1}{48}$
0.04403	0.03583	0.03333	0.02748	0.01634	0.02083
$\frac{12\pi^2-35}{16\pi^2}$	$\frac{3\pi-8}{8\sqrt{2}-1}$	$\frac{2}{5}$	$\frac{80\pi^2-373}{128\pi^2}$	$\frac{\pi^2-6}{2\pi^2}$	$\frac{1}{4}$
0.52836	0.42996	0.40000	0.32974	0.19604	0.25000
$\frac{12\pi^2-35}{144\pi^2}$	$\frac{3\pi-8}{24(\pi-2)}$	$\frac{1}{20}$	$\frac{80\pi^2-373}{960\pi^2}$	$\frac{\pi^2-6}{12\pi^2}$	$\frac{1}{24}$
0.05871	0.05200	0.05000	0.04397	0.03267	0.04167
$\frac{12\pi^2-35}{12\pi^2}$	$\frac{3\pi-8}{2(\pi-2)}$	$\frac{3}{5}$	$\frac{80\pi^2-373}{80\pi^2}$	$\frac{\pi^2-6}{\pi^2}$	$\frac{1}{2}$
0.70448	0.62403	0.60000	0.52759	0.39207	0.50000

‡ The entries in these lines assume that the vessel is flat-bottomed, with vertical sides. The other entries hold good whatever may be the shape of the vessel under water. In general, the height of the metacenter may be found by dividing the entry in lines 5 or 6 by the displacement.

Effect of Form of Water Line

From J. Scott Russell,

Length of vessel $= L$.* Breadth on water line

	ALGEBRAIC FACTOR.	(1) Square, or Rectangle.	(2) Square, with Semi-circular Ends.	(3) Circular or Elliptic Form.
1 Area of plane of flotation ‡ .	LB	1	$\frac{4+\pi}{8}$	$\frac{1}{4}\pi$
2 The same, expressed decimally ‡	LB	1.00000	0.89270	0.78540
3 Ratio to same in rectangular form	. .	1	$\frac{4+\pi}{8}$	$\frac{1}{4}\pi$
4 The same, expressed decimally	. .	1.00000	0.89270	0.78540
5 $\int \frac{1}{3} y^3 dx$ ‡	LB^3	$\frac{1}{12}$	$\frac{16+3\pi}{384}$	$\frac{1}{64}\pi$
6 The same, expressed decimally‡	LB^3	0.08338	0.06621	0.04909
7 Ratio to same in rectangular form	. .	1	$\frac{16+3\pi}{32}$	$\frac{3}{16}\pi$
8 The same, expressed decimally	. .	1.00000	0.79452	0.58905
9 Height of metacenter above center of displacement § .	$\frac{B^2}{\text{dr.}}$	$\frac{1}{12}$	$\frac{16+3\pi}{12(16+4\pi)}$	$\frac{1}{16}\pi$
10 The same, expressed decimally §	$\frac{B^2}{\text{dr.}}$	0.08333	0.07417	0.06250
11 Ratio to same in rectangular forms	. .	1	$\frac{16+3\pi}{16+4\pi}$	$\frac{3}{4}\pi$
12 The same, expressed decimally§	. .	1.00000	0.89003	0.75000

* The length L appears simply as a factor. The numerical factor in the table, therefore, remains unchanged, if the proportion of L to B be altered, as in passing from the square to the rectangle, or from the circle to the ellipse.

† That is to say, a trochoid twice the length of the cycloid of the same width.

on Position of Metacenter.

Nav. Arch., 1865.

amidships $= B$. Draught of water $=$ dr.

NUMERICAL FACTOR FOR					
(4) Cycloid (a Full Wave Stern).	(5) Circular Segment (Arc of 90°).	(6) Parabola (Axis Athwartships).	(7)† Trochoid 1 : 2 (a Wave Stern).	(8) Curve of Sines (a Wave Entrance).	(9) Wedge.
$\frac{3}{4}$	$\frac{\pi - 2}{4(\sqrt{2} - 1)}$	$\frac{2}{3}$	$\frac{5}{8}$	$\frac{1}{2}$	$\frac{1}{2}$
0.75000	0.68901	0.6667	0.6250	0.50000	0.50000
$\frac{3}{4}$	$\frac{\pi - 2}{4(\sqrt{2} - 1)}$	$\frac{2}{3}$	$\frac{5}{8}$	$\frac{1}{2}$	$\frac{1}{2}$
0.75000	0.68901	0.6667	0.62500	0.50000	0.50000
$\frac{35}{768}$	$\frac{1}{24} \cdot \frac{9\pi - 28}{20\sqrt{2} - 28}$	$\frac{4}{105}$	$\frac{55}{1536}$	$\frac{5}{192}$	$\frac{1}{48}$
0.04557	0.04021	0.03810	0.03581	0.02608	0.02083
$\frac{35}{64}$	$\frac{1}{2} \cdot \frac{9\pi - 28}{20\sqrt{2} - 28}$	$\frac{16}{35}$	$\frac{55}{128}$	$\frac{5}{16}$	$\frac{1}{4}$
0.54688	0.48252	0.45714	0.42969	0.31250	0.25000
$\frac{35}{576}$	. . . .	$\frac{2}{35}$	$\frac{11}{192}$	$\frac{5}{96}$	$\frac{1}{24}$
0.06076	0.05836	0.05714	0.05729	0.05208	0.04167
$\frac{35}{48}$	. . . .	$\frac{24}{35}$	$\frac{11}{16}$	$\frac{5}{8}$	$\frac{1}{2}$
0.72917	0.70031	0.68571	0.68750	0.62500	0.50000

‡ These are all areas or moments, and therefore, for compound forms, it is only necessary to add them, or take a mean of them, as may suit the particular case.

§ The entries in these lines assume that the vessel is flat-bottomed, with vertical sides. The other entries hold good, whatever may be the shape of the vessel under water. In general, the height of the metacenter may be found by dividing the entry in lines 5 or 6 by the displacement.

Modulus of Fineness.—Lines 11 and 12 enable us to compare the different forms; and by running our eye along line 12 we are enabled to trace the effect of the successive changes in the form of water line, in bringing down the metacenter, and reducing the stability of the ship, thus giving what has been sometimes called the modulus of fineness of water line.

STABILITY CALCULATION, USING THE INTEGRATOR AND APPLYING TCHIBYSCHEFF'S RULE.

The following tables will show the application of the above rule to the calculation of the stability levers GZ from the body plan reproduced, noting that the integrator used was metrically divided, and the original drawing was to a scale of $\frac{1}{8}$ to the foot or $\frac{1}{96}$ full size with ten Tchibyscheff ordinates. The center of gravity was assumed at 24 feet above base. The coefficients are therefore as follows, the length of vessel being 600 feet:—

For displacements (tons),

$$\frac{600}{10} \times \frac{96^2 \times 3.281^2}{100 \times 35} = 1701.5.$$

For levers (feet),

$$.06 \times 96 \times 3.281 = 18.9.$$

and,

Displacement in tons =

$$1701.5 \times \text{sum of differences of area readings.}$$

$$\text{Levers in feet} = \frac{18.9 \times \text{sum of differences of moment readings}}{\text{Sum of differences of area readings}}.$$

or,

$$\left.\begin{array}{ll} \text{Displacements } (D) = 1701.5 \times I \\ \text{Levers } (GZ) \quad = \quad 18.9 \times \dfrac{II}{I} \end{array}\right\} \begin{array}{l} I \text{ respective to } II \text{ taken up} \\ \text{to the corresponding water} \\ \text{lines.} \end{array}$$

The angles calculated were 15°, 30°, 45°, 60°, 75°, and 90°, and the results as tabulated used to plot off the Stability Cross Curves shown from which the Stability Curves at various displacements were taken, the correction being calculated for the new locii of the center of gravity where G is the assumed position *below* S then $GZ = SZ + SG \sin \theta$, and when *above* S then $GZ = SZ - SG \sin \theta$. So that taking the ordinates from the cross curves at the displacement dealt with SG being now known, we can determine the exact values of GZ for any angle.

Stability Calculations

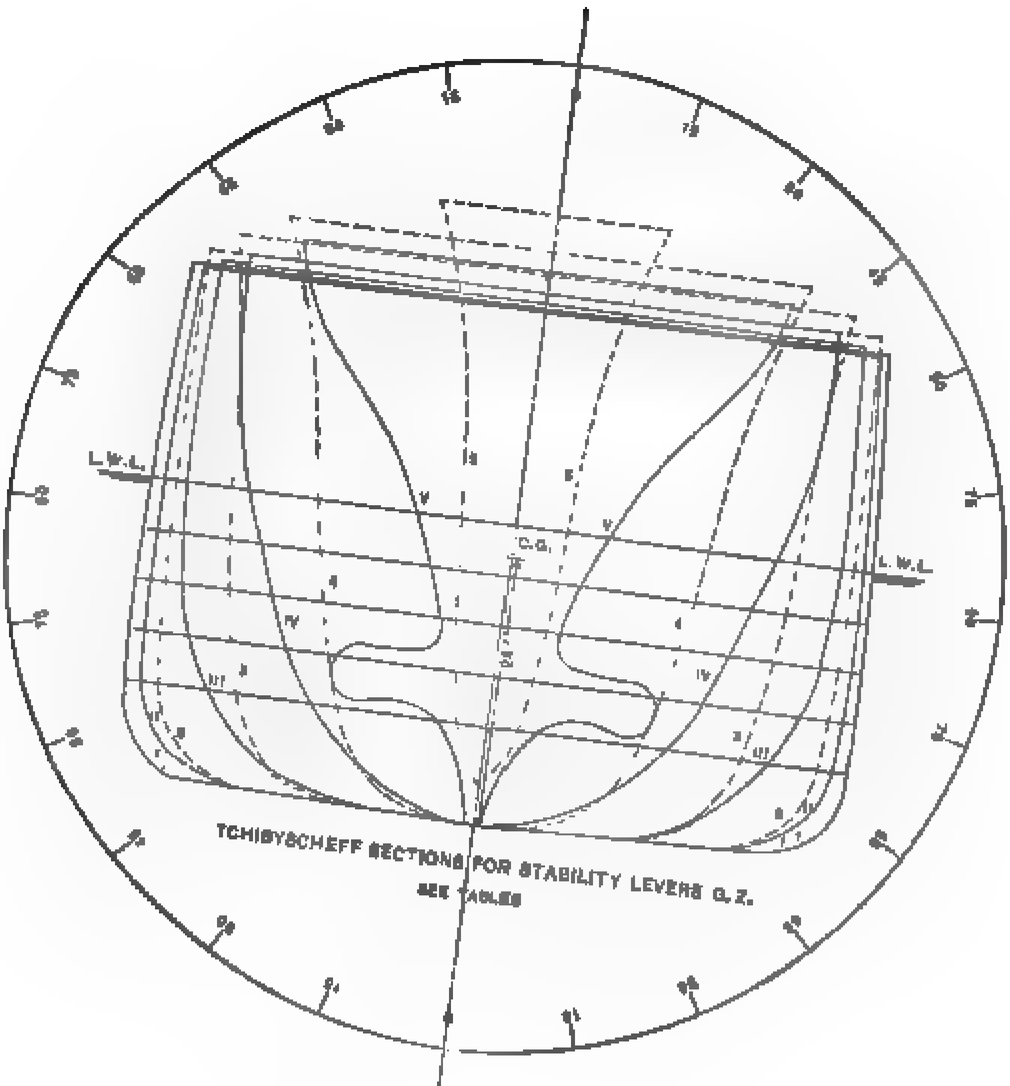


Fig. 9.

Calculation of GZ Levers for Stability Cross Curves, Using the Integrator and Tchibyscheff's Rule.

Inclination.	Water Lines.	Area Readings. A	Differences of Readings.	Sum of Differences. I	Displacement in Tons. D	Moment Readings. M	Differences of Readings.	Sum of Differences. II	Stability Levers. GZ
15°		4555				4511			
	5	7666	3111	3.111	5,290	5097	+.586	+.586	3.560
		7666				5097			
	4	9668	2002	5.113	8,700	4931	–.166	+.420	1.550
		9668				5169			
	3	1779	2111	7.224	12,280	4974	–.195	+.225	.590
		1779				5211			
	2	3896	2117	9.341	15,900	5141	–.070	+155	.314
		3896				5378			
	L.W.L.	6115	2219	11.560	19,700	5423	+.045	+200	.327
		6115				5661			
	L.W.L.	7685	. . .	11.570	. . .	5863	. . .	+202	Check
30°		0625				5060			
	5	3766	3141	3.141	5,350	5820	+.760	+.760	4.570
		3766				6079			
	4	5578	1812	4.953	8,440	6122	+.043	+.803	3.070
		5578				6380			
	3	7681	2103	7.056	12,000	6317	–.063	+.740	1.980
		7681				6575			
	2	9980	2299	9.355	15,920	6525	–.050	+.690	1.395
		9980				6784			
	L.W.L.	2411	2431	11.786	20,050	6963	+.179	+.869	1.386
		2411				7221			
	L.W.L.	4201	. . .	11.790	. . .	8091	. . .	+.870	Check
45°		8309				9862			
	5	1620	3.311	3.311	5,640	0549	+.687	+.687	3.930
		1620				0549			
	4	3412	1792	5.103	8,680	0820	+.271	+.958	3.550
		3412				1056			
	3	5519	2107	7.210	12,250	1411	+.355	+1.313	2.950
		5519				1647			
	2	7874	2355	9.565	16,300	1999	+.352	+1.665	3.260
		7874				2235			
	L.W.L.	0365	2491	12.056	20,400	2463	+.228	+1.893	2.970
		0365				2699			
	L.W.L.	2423	. . .	12.058	. . .	. . .	. . .	1.896	Check

Calculation of GZ Levers for Stability Cross Curves, Using the Integrator and Tchibyscheff's Rule.

Inclination.	Water Lines.	Area Readings. *A*	Differences of Readings.	Sum of Differences. *I*	Displacement in Tons. *D*	Moment Readings. *M*	Differences of Readings.	Sum of Differences. *II*	Stability Levers. *GZ*
		6097				4869			
	5	9808	3711	3.711	6,315	5547	+.678	+.678	3.46
		9808				5547			
	4	1684	1876	5.587	9,520	6051	+.504	+1.182	4.00
		1684				6285			
60°	3	3746	2062	7.649	13,000	6637	+.352	+1.534	3.80
		3746				6871			
	2	5976	2230	9.879	16,800	7186	+.315	+1.849	3.50
		5976				7420			
	L.W.L.	8241	2265	12.144	20,550	7544	+.124	+1.973	3.07
		8241				7778			
	L.W.L.	0389	. . .	12.148	. . .	9754	. . .	+1.976	Check
		0622				1355			
	5	4832	4210	4.210	7,160	2078	+.723	+.723	3.25
		4832				2078			
	4	6676	1844	6.054	10,300	2448	+.370	+1.093	3.42
		6676				2920			
75°	3	8599	1923	7.977	13,600	3166	+.246	+1.339	3.18
		8599				3402			
	2	0689	2090	10.067	17,130	3503	+.101	+1.440	2.70
		0689				3740			
	L.W.L.	2860	2171	12.238	20,800	3890	+.150	+1.590	2.46
		2860				4137			
	L.W.L.	5090	. . .	12.230	. . .	5737	. . .	+1.600	Check
		0521				5890			
	5	5039	4518	4.518	7,690	6332	+.442	+.442	1.85
		5039				6332			
	4	6783	1744	6.262	10,560	6438	+.106	+.548	1.65
		6783				6674			
90°	3	8637	1854	8.116	13,810	6767	+.093	+.641	1.49
		8637				7004			
	2	0685	2048	10.164	17,295	7128	+.124	+.765	1.42
		0685				7364			
	L.W.L.	2880	2195	12.359	21,030	7436	+.072	+.837	1.29
		2880				7672			
	L.W.L.	5242	. . .	12.362	. . .	8511	. . .	+.839	Check

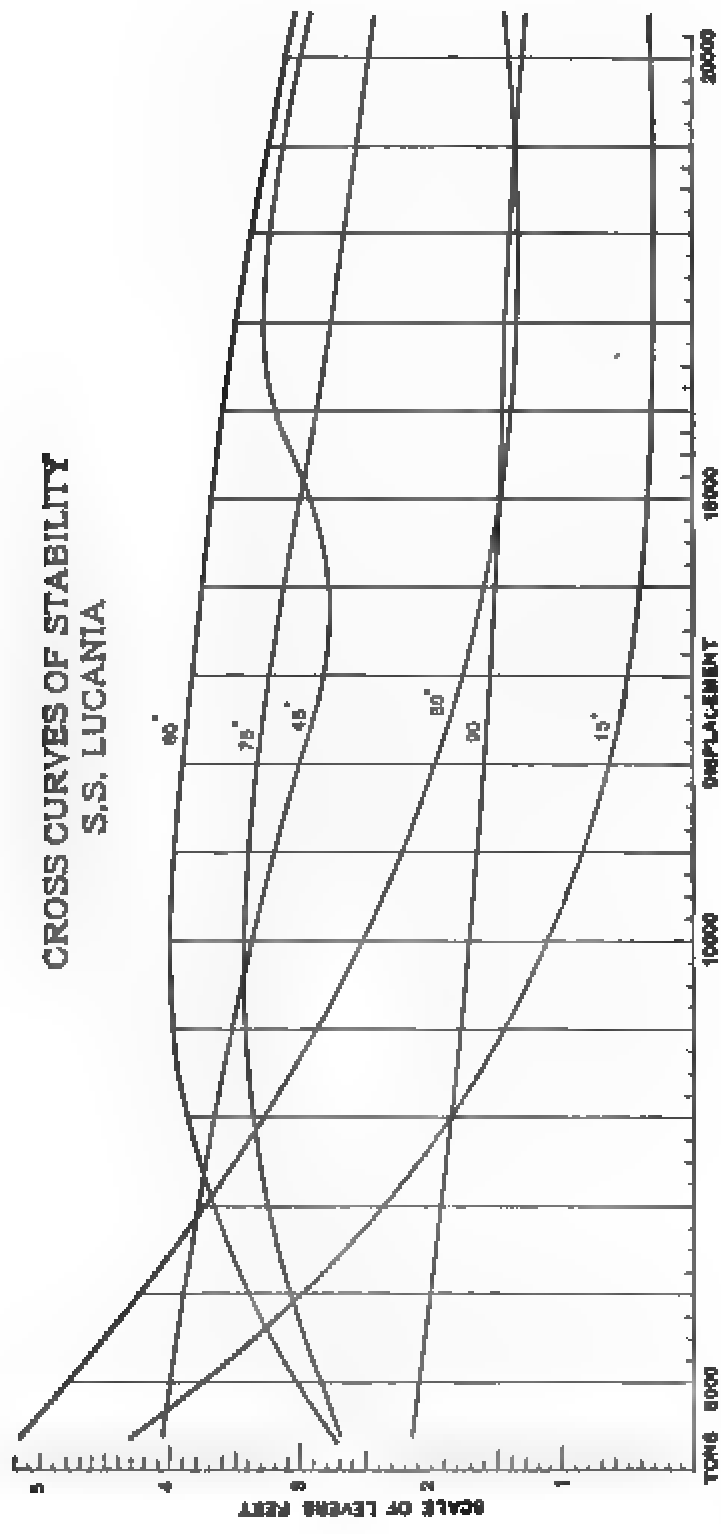

CROSS CURVES OF STABILITY
S.S. LUCANIA
90°
75°
45°
60°
30
15°
TONS 5000
10000
15000
20000
DISPLACEMENT
5
4
3
2
1
SCALE OF LEVERS FEET

Fig. 10.

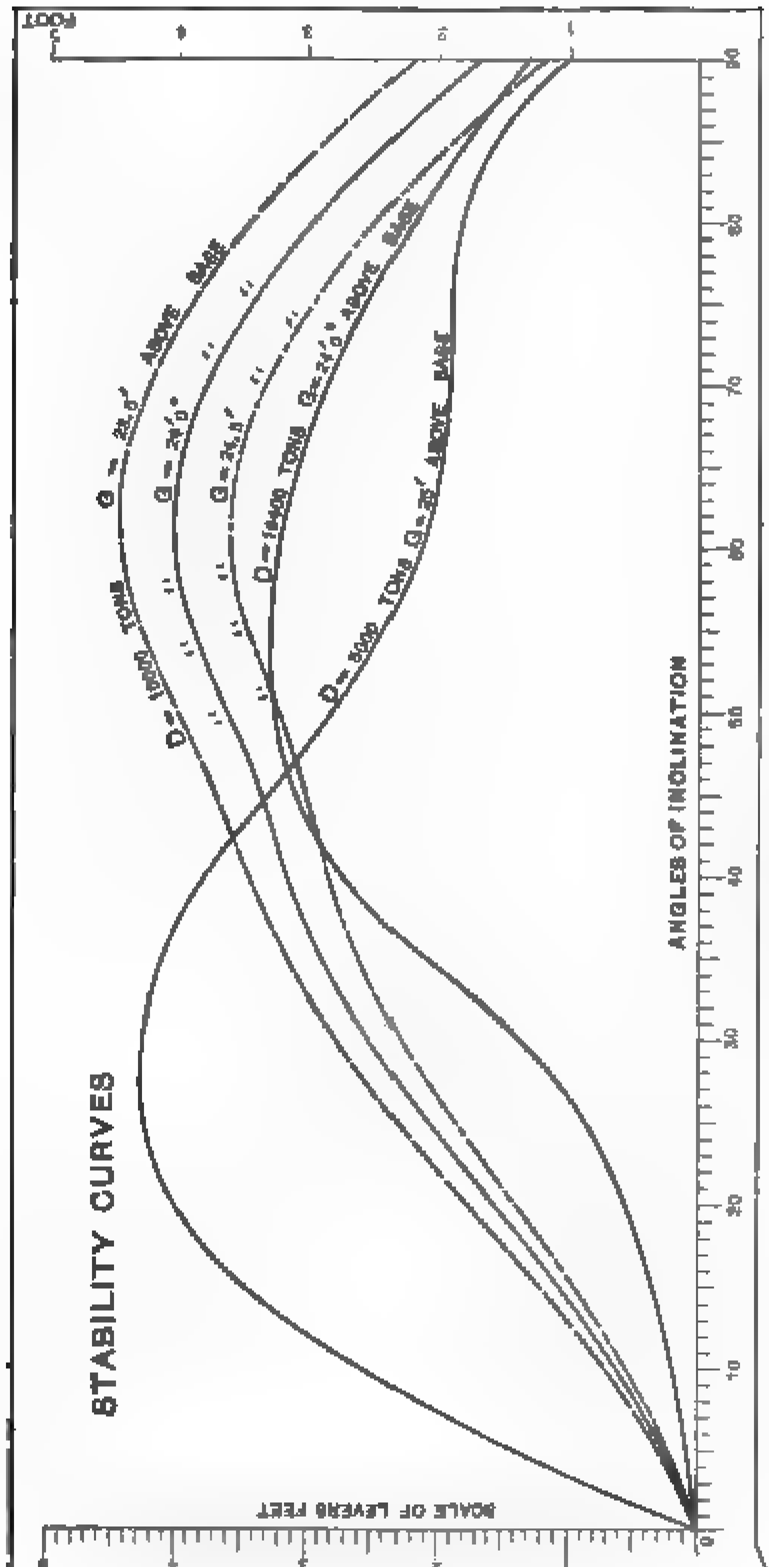

STABILITY CURVES
ANGLES OF INCLINATION
SCALE OF LEVERS FEET
FOOT

FIG. 11.

CHAPTER II.

DESIGN.

In the foregoing pages we have treated with the various calculations which confront the naval architect, but the relation of these to one another and to the particular qualities that the projected ship shall possess belong to Design.

In designing the ship, nothing should be left to chance, or what is the same thing — trial and error. The vessel must first be designed with figures. Before a single line is run on paper, the various element coefficients should be carefully selected and their functions worked out in consonance with the results desiderated in the finished ship. The relation of these coefficients to one another must be firstly mastered for all types of vessels and conditions of draught and trade, when with the aid of the tables given an unerring selection will be possible and a definite result attained.

When the way is prepared for the drawing part of the design to be taken in hand, it will be found advantageous to have a definite routine in which to prepare the various views comprised under the general term "Lines." Each step should be taken in its proper time and order. Much time will thus be gained, and a clearer conception of the art of designing obtained. To this end we submit the following method as one fulfilling these propositions, dividing the task broadly into two parts, viz.: —

(*a*) Figures and (*b*) Lines, the first embracing the moulded dimensions, draught, element coefficients, and their functions, and the latter, the sheer draught, half-breadth, and body plans.

The shipowner will specify the trade for which the ship is intended and the limit of draught on the particular service proposed. It will generally be found economical to take advantage of the maximum draught permissible. When the dimensions are solved to meet the requirements stipulated, the grade numerals should be worked out, for the Classification Society's Rules in which it is proposed to class the ship, and if it be found that a grade can be saved either in plating, framing or equipment numerals, or the requirements for extreme proportions evaded by a *slight* alteration or adjustment of the dimensions, this of course should be done.

As an example we shall postulate that the shipowner requires a 3-deck freighter with complete shelter deck to carry 10,000 tons dead weight, *exclusive* of coal for 12 days' steaming, fresh water and stores, on a mean draught of 27 feet with a B.T. Freeboard and a sea speed of 12 knots. The ship to be classed in American Record and to conform to the U.S. Inspection Laws. To these

demands of the owner the naval architect should add the G.M. when fully loaded with a homogeneous cargo. Let us call this 1.5 ft.

The first point to determine is the amount of displacement we shall require to provide for over and above the specified dead weight of 10,000 tons, to allow for weight of finished ship and machinery, coal, fresh water, and stores. At this stage we cannot calculate these items, as we are uninformed as to the dimensions of the ship, so that the remaining method to solve this is to estimate a weight embracing all of these items based on a percentage of the dead weight. This percentage of course is determined from vessels of similar type and trade duly worked out and tabulated by the naval architect. We shall take, then, each step in its proper order :

(1) Displacement = dead weight × 1.64 = 16,400 tons.

(2) Block coefficient "δ" $= \alpha.\beta.\epsilon. = .79$.

(3) Relation coefficient "ϵ" $= \dfrac{\delta}{\alpha.\beta} = .945.$*

(4) Mid. area coefficient "β" $= \dfrac{\delta}{\alpha.\epsilon} = .97.$

(5) Prismatic coefficient "p" $= \dfrac{\delta}{\beta} = .814.$

(6) Area of L.W.L. coefficient "α" $= \dfrac{p}{\epsilon} = .861.$

(7) Moment of inertia coefficient "i" (see table) = .0638.

(8) B.M. coefficient "m" $= \dfrac{i}{\delta} = .08.$

(9) Center of gravity coefficient "g" $= \dfrac{G}{H} = .559.$ (See table.)

(10) Depth "H" to upper deck per Freeboard Tables = 33.5 ft.

(11) Depth "H_1" to shelter deck $= H + 7.5$ ft. = 41 ft.

(12) Center of gravity above base $= H_1 \times g = 41 \times .559 = 22.90$ ft.

(13) Metacenter above base = C.G. + G.M.
$= 22.90 + 1.50 = 24.40$ ft.

(14) Breadth "B" to give M.C. of 24.4 ft. =

$$\sqrt{\left[M-d\left(\frac{5a-2\delta}{6a}\right)\right]\times\frac{d}{m}}=58.5\text{ feet, and } M=\frac{B^2\times m}{d}+d\,\frac{(5a-2\delta)}{6a}.$$

(15) Length "L" $= \dfrac{V\cdot A}{B \times d \times \delta} = 460$ ft.

(16) B.M. $= \dfrac{L \times B^3 \times i}{V} = \dfrac{I}{V} = 10.23$ ft.

(17) Center of buoyancy above base

$$= d\left(\frac{5a-2\delta}{6a}\right) = 14.25 \text{ ft.}$$

* May be taken constant .9, as per table.

(18) Bilge diagonal coefficient (see diagram) = .82.
(19) Dimensions as determined = 460 × 58′ 6″ × 33′ 6″.
(20) Displacement "D"

$$= \frac{460' \times 58.5' \times 27'}{35} \times .79 = 16{,}400 \text{ tons.}$$

(21) Calculated weights:

Hull complete	4,670	tons	
Machinery	730	"	(4,000 I.H.P.)
Coal	750	"	(for 12 days)
Fresh water	200	"	
Stores	50	"	
	6,400	"	
Dead weight	10,000	"	
Displacement =	16,400	tons	

Should it be found, however, that the weights calculated for the dimensions as worked out are lighter than anticipated when we started with the 64 per cent of the dead weight, the *length* should be reduced accordingly. On the other hand, if the weights be excessive, the length must be increased. The length is the only dimension that should be adjusted, as it is the one factor which has no vital relationship to the element coefficients, as it will have been noticed that the primary quality aimed at was the G.M. as a measure of the ship's initial stability; and as the center of gravity varies with the depth, so the metacentric height is dependent on the breadth and draught.

For the preliminary design it will be sufficiently close to estimate the machinery weights on the I.H.P. required, and for ordinary merchant practice the power may be calculated fairly accurately by the Admiralty constant with the formula:—

$$\text{I.H.P.} = \frac{D^{\frac{2}{3}} \times V^3}{C}.\ *$$

We then have for the present example, with constant = 267, speed 12 knots, and displacement 16,400, an indicated horse-power = 4000. By referring to the table given elsewhere, it will be found that for twin screw freight steamers with this speed that the I.H.P. per ton of engine boilers and water equals about 5.5, so that we get for a total machinery weight

$$\frac{4000}{5.5} = 730 \text{ tons.}$$

The displacement and coefficients should, in all cases of steel steamers, be calculated to the moulded line of frames, the excess water displaced by the shell plating, amounting to about 1%, being retained in hand as a margin against contingencies. In this case its value is 164 tons, representing 3 inches of draught.

* See Table of Constants, and chapter on Resistance.

Relation of the Coefficients to One Another.

Relation coefficient, $\epsilon = .9$, constant $= \dfrac{p}{a}$.

Block coefficient, $\delta = a.\beta.\epsilon$.

Area of water line coefficient,

$$a = \frac{p}{\epsilon}, \text{ or } \frac{\delta}{\beta.\epsilon}.$$

Mid. area coefficient, $\beta = \dfrac{\delta}{p}$, or $\dfrac{\delta}{a.\epsilon}$

Prismatic coefficient, $p = \dfrac{\delta}{\beta}$.

Bilge diagonal coefficient,

$$b = \frac{p}{.92} \text{ to } \frac{p}{.99} \; (p = .6 \text{ to } .82).$$

Type of Vessel.	ϵ	δ	a	β	p	b
Steam pinnaces, 30 ft. to 60 ft.	.9	.36	.666	.600	.600	.652
	.9	.36	.606	.616	.600	.652
Steam yachts, 100 ft. to 300 ft., also destroyers and torpedo craft	.9	.38	.666	.633	.600	652
	.9	.39	.666	649	600	.652
	9	.40	.666	.666	.600	652
	.9	.41	.670	.680	.608	.658
	.9	.42	.671	.695	604	.653
	.9	.43	671	.712	.604	653
Small river propeller steamers, 50 ft. to 150 ft.	.9	.45	.675	.740	.608	.654
	.9	.46	.674	.758	.607	.654
	.9	.47	.674	.774	.607	.654
	.9	.48	.675	.790	.608	.655
	.9	.49	.676	.804	609	656
	.9	.50	.677	.820	.610	.657
Sound and river steamer, 150 ft. to 400 ft.	.9	.51	.679	834	.611	.659
	.9	.52	.680	.849	.612	.661
	.9	.53	.683	.860	615	663
	.9	.54	.688	.870	.620	665
	.9	.55	.694	.880	.625	.670
	.9	.56	.700	.890	.630	.676
	.9	57	.703	.900	.633	.679
	9	58	.707	.910	.637	.683
	.9	.59	.712	.920	.641	.687
	.9	60	.716	.930	.645	.692

Type of Vessel.	ϵ	δ	α	β	p	b
High speed channel steamers, 200 ft. to 300 ft.	.9	.58	.677	.950	.610	.657
	.9	.59	.689	.953	.620	.665
	.9	.60	.697	.956	.627	673
	.9	.61	.707	.959	.636	.681
	.9	.62	.716	.962	644	.690
Ocean liners, 400 ft. to 750 ft.	.9	.63	.725	.965	.652	.698
	.9	.64	.734	.968	.661	.706
	.9	.65	.743	.971	.669	.714
	.9	.66	.755	.975	.680	.722
Full-rigged ships, 250 ft. to 350 ft.	.9	.70	.820	.950	.737	.768
	.9	.71	.828	.952	.745	.770
	.9	.72	.838	.954	.754	.777
	.9	.73	.847	.957	.762	.785
	.9	.74	.857	.959	.771	.792
Intermediate liners and freighters, 300 ft. to 700 ft.	.9	.75	.866	.962	.779	.800
	.9	.76	.874	.965	.787	807
	.9	.77	.884	.967	.796	.814
	.9	.78	.894	.969	.805	.819
	.9	.79	.903	.971	.813	.825
	.9	.80	913	.973	.822	.830
	.9	.81	.922	.976	.830	.836
	.9	.82	.933	.978	.840	.843
	.9	.83	.941	.980	.847	.850

Coefficients of Centers of Gravity for Various Vessels.

	Value of "g."
Small steamers, as harbor tenders, revenue steamers, etc.	.65 to .70
Torpedo boats	.67
Torpedo boat destroyers	.55 to .60
Auxiliary steam yachts	.65
Full-power steam yachts	.70
Full-rigged sailing ships	.69 to .71
Shelter-deck intermediate liners	.60 to .65
Swift ocean liners	.56 to .58
Shelter-deck freighters	.56 to .58
Three-deck freighters, with poop, bridge, and forecastle	.54 to .56

Moment of Inertia of Water Line Coefficients.

$$L \times B^3 \times i = I.$$

Water Line Coefficient, "a."	Inertia Coefficient, "i."	Water Line Coefficient, "a."	Inertia Coefficient, "i."
.50	.02250	.75	.04841
.51	.02316	.76	.04966
.52	.02383	.77	.05100
.53	.02466	.78	.05233
.54	.02540	.79	.05383
.55	.02633	.80	.05500
.56	.02710	.81	.05650
.57	.02800	.82	.05783
.58	.02910	.83	.05930
.59	.03000	.84	.06075
.60	.03100	.85	.06200
.61	.03200	.86	.06341
.62	.03300	.87	.06500
.63	.03400	.88	.06625
.64	.03500	.89	.06766
.65	.03600	.90	.06900
.66	.03733	.91	.07050
.67	.03844	.92	.07200
.68	.03955	.93	.07341
.69	.04100	.94	.07500
.70	.04200	.95	.07600
.71	.04325	.96	.07833
.72	.04500	.97	.07900
.73	.04600	.98	.08050
.74	.04700	. . . .	. . . .

All the elements insuring the qualities that embody a well-shaped boat of the particular type contemplated and at the same time a stable ship having been thus determined, the lines may be commenced with the certainty that no unnecessary alterations will be required.

The freeboard will be calculated from the legal tables given and explained herein, but in any case the limiting draught consistent with the block coefficient determined on as the maximum available for the required speed should be taken advantage of.

After carefully drawing the center and other construction lines, and marking off the ten or twenty ordinates that it is proposed to

use, it will be well to have a definite routine or method in whicl to draw down the various views comprising what are embracec under the general term "lines."

To this end the following will prove a good sequence:

1. The "dead flat" section on body view.
2. Rail sheer line.
3. Contour of stem and stern in profile.
4. Rail half-breadth.
5. Load water line half-breadth.
6. Bilge diagonal.
7. Transfer L.W.L. and B.D. $\frac{1}{2}$-breadths to body plan.
8. Draw freehand the sections to foregoing.
9. Trial displacement by planimeter.
10. Sheer heights from profile to body plan.

Taking this routine in order: —

1st. The dead flat or midship section should present no difficul ties, as the area of this section is pre-determined from the co efficient β. This being so, the height of rise of floor constructio line is assigned by giving the easiest bilge consistent with th area of section demanded. In no case should the bilge b "squarer" than the demands of this area require, as in ful vessels sufficient difficulty is encountered in setting the bilge strak plates and bending the frames without adding further to it.

2d. In most vessels, except yachts and launches, it will b found advisable to make the lowest part of sheer at the half-lengt amidships, as otherwise correction would have to be made fo freeboard and the classification societies' numerals. It is best then, after fixing the height of bulwark or sheer strake abov upper deck to underside of moulding, to run a pencil line parall to L.W.L. from A.P. to F.P., at which points and above this lin the sheer forward and aft should be set up. The amount of shee will of course depend on the type of vessel, *i.e.* whether intende for sea or river. In the latter case it is evident the same amour of "spring" would not be required as for over-sea voyages. Th standard sheer prescribed by the British freeboard tables will be however, a good guide, and where this is deemed insufficient c where special cases suggest a departure from these, as in passenge steamers and first class ocean liners, a handy rule and one that give a very symmetrical sheer is to take one-fifth of the vessel's lengt in feet, calling the quotient inches which will equal the amour of sheer forward. One-third of this will be the sheer aft, as: —

$$\frac{\text{Length in feet}}{5} = \text{Sheer forward in inches,}$$

and,

$$\frac{\text{Sheer forward}}{3} = \text{Sheer aft in inches.}$$

The amount of sheer having been decided upon with the lowest part, say, at the half-length, the quickest and simplest way to run the sheer line, insuring a fair curve, will be to divide the half-length before and abaft the lowest sheer, into four equal parts, and at each of these points set up the perpendicular heights obtained, as under, postulating in this case that the sheer at F.P. is equal to 82 inches, and the sheer at A.P. 30 inches, giving a mean sheer of 56 inches, as per freeboard tables.

$82'' \times 1.000 = 82''$ sheer at 4th station = F.P.
$82'' \times .562 = 46''$ sheer at 3rd station forward of lowest
$82'' \times .250 = 20\frac{1}{2}''$ sheer at 2d station forward of "
$82'' \times .0625 = 5\frac{1}{8}''$ sheer at 1st station forward of "

and for the sheer aft: —

$30'' \times 1.000 = 30''$ sheer at 4th station = A.P.
$30'' \times .562 = 16\frac{7}{8}''$ sheer at 3d station abaft lowest
$30'' \times .250 = 7\frac{1}{2}''$ sheer at 2d station abaft "
$30'' \times .0625 = 1\frac{7}{8}''$ sheer at 1st station abaft "

By pinning the spline to these spots and adjusting the free ends to the eye, an absolutely fair sheer line may be run in, bearing in mind, however, that in ships with a very full rail line forward, compensation must be given on the sheer to adjust the great disparity in the length of the half-breadth rail line and the same line projected on sheer plan; as, if this be not done, the rail line on model, and of course on the actual ship, will appear as "rounding down."

3d. The contour line of the stem will be very much a matter of individual taste, although above water line it is usual to make it straight unless in special cases. By "straight" is meant "apparently" so, as it is customary to give about ¼-inch round on face of stem from where it leaves the top of the forefoot curve to stem head, an absolutely straight line adjoining a curve *appearing* as slightly hollow. Also, it is not advisable to make the stem plumb, as the illusion in that case is to make it appear as leaning aft. A rake forward of about twice the moulding of the stem head is common. In outlining the stern and counter the same remarks as to taste apply, care being taken that the counter line where it meets the rudder post is carried by an imaginary curve to harmoniously meet the arch of body post. The counter line, from knuckle moulding to stern post, should be perfectly straight — *not* hollow. A hollow to this line gives the appearance of an overweighted overhang, and a broken sheer, besides making the plating more difficult to set.

Dimensions of Figureheads and Lacing Pieces.

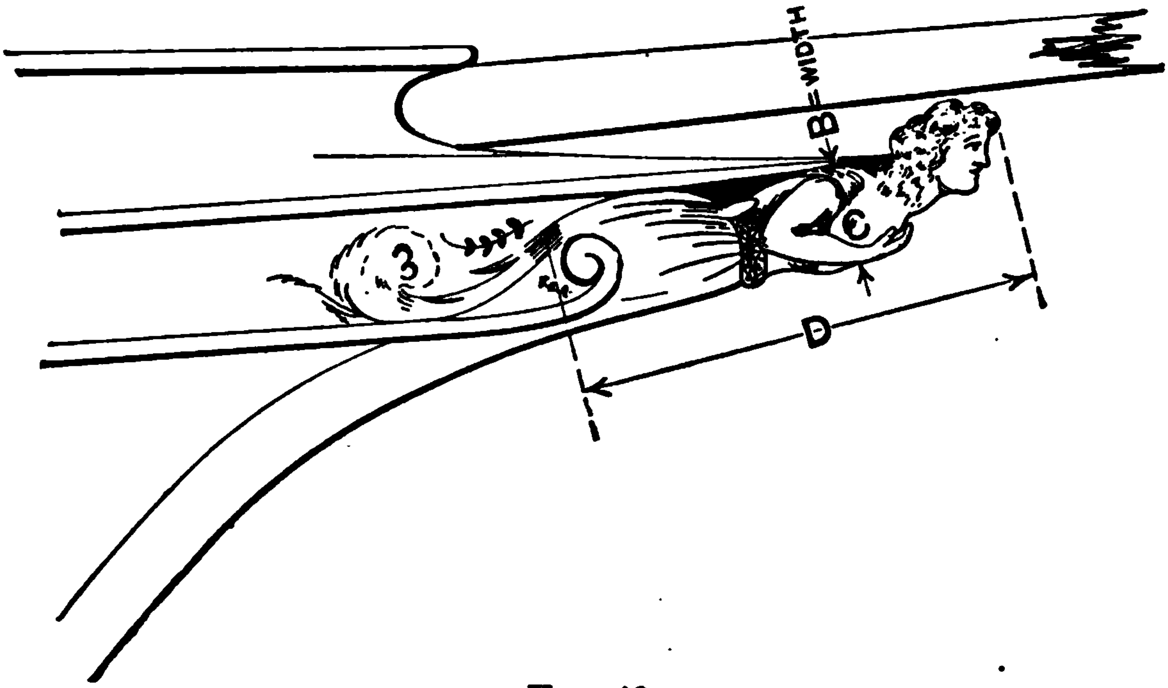


FIG. 12.

A Length of Vessel, B. S.	*B* Size of Lacing Piece.	*C* Depth of Figure-head.	*D* Length of Figure Outside of Stem.	
Feet.	Inches.	Inches.	Feet.	Inches.
450	$12\frac{3}{4}$	$30\frac{1}{4}$	9	6
400	12	$28\frac{1}{2}$	9	0
350	$11\frac{1}{4}$	$26\frac{3}{4}$	8	6
300	$10\frac{1}{2}$	25	8	0
250	$9\frac{3}{4}$	$23\frac{1}{4}$	7	6
200	9	$21\frac{1}{2}$	7	0
150	$8\frac{1}{4}$	$19\frac{3}{4}$	6	6
100	$7\frac{1}{2}$	18	6	0

NOTE.—Angle of lacing piece, 45°.

The length of overhang of course cannot be arbitrarily fixed but a very fair proportion for ordinary freighters is $\frac{1}{30}$ to $\frac{1}{35}$ of th length. The height of deck or rail at taffrail, or "cock-up," wil be dependent on the camber of deck at transom frame (No. 0) The midship camber proportioned to the half-breadth at thi frame should be set up and the deck line carried through thi spot in a fair curve to taffrail. The height so obtained should b then transferred to body plan, and the deck (or rail line) betwee No. 0 section and taffrail drawn in as a round of beam curve, fron

which may be obtained the intermediate spots for deck at side (or rail) on sheer plan.

4th. The rail half-breadth will depend on the particular type of ship being designed. In freighters it will be parallel to the center line for probably half the length amidships, whereas in yachts and other fine vessels it will "round" all the way. It is convenient to have rail half-breadths at hand for various types of vessels for, say, ten ordinates with half-end ordinates or whichever number is adopted as the standard. These should be tabulated with the half-breadth amidships as unity, when, with the aid of a slide rule, the half-breadths for the design may be very rapidly proportioned. It will be found convenient to have these for liners, freighters, sound and river steamers, yachts, etc., from good examples of their respective classes. The contour of rail line around taffrail will require careful fairing into the A.P. ordinate spot, and also at center line, where in no case should it be perfectly straight, the effect of such being a hollow. Neither, on the other hand, should it come to a "peak" or point, but carefully drawn as an arc of a circle. The knuckle mouldings, whether they be one or more, may with advantage be delineated by tracing the rail line just drawn and transferring it forward to its exact location. By so doing it will be seen that the stern between knuckle and rail lines will develop with a pleasing gradation from "O" frame to the upper counter line.

Table of Rail Half-Breadths for Various Types.

Ordinates. "0"=A.P.	Ocean Liner.	Freighters.	Steam Yachts.	River Steamers.	Sailing Ships.	Steam Launches.	Oceanic.
0	.630	.444	.756	.756	.603	.603	.655
½	.714	.757	.812	.829	.730	.691	.790
1	.786	.889	.854	.872	.810	.772	.845
2	.882	.990	.918	.934	.910	.875	.912
3	.946	1.000	.951	.977	.967	.955	.965
4	.985	1.000	.988	.994	.979	.995	.987
5=	1.000	1.000	1.000	1.000	1.000	1.000	1.000
6	.989	1.000	.991	.994	.979	.978	.971
7	.934	1.000	.965	.965	.960	.930	.944
8	.820	.985	.891	.877	.910	.803	.884
9	.594	.856	.727	.619	.740	.532	.666
9½	.358	.572	.576	.366	.515	.298	.404
10	Stem	Stem	.355	Stem	Stem	Stem	Stem

5th. The load water line, as already stated, must circumscribe the area calculated with the aid of the coefficient a. The method of obtaining a has been previously explained. To obtain the form of this water line, and at the same time insure the accuracy of the required enclosed area, it will be found advantageous to prepare a diagram similar to the one opposite, or this one may be used with the aid of proportional compasses. Opposite the value of a for the design in hand half-breadths for ten ordinates may be read off and transferred to the half-breadth plan. Should, however, the line delineated after the spline has been fixed not meet with the designer's individual taste, or where greater fullness or fineness is required for special cases, forward or aft, it will be a very simple matter to modify the line, at the same time observing that whatever area be cut off at any one point be compensated for elsewhere on the water line, as the offsets taken from the diagram will enclose exactly the area required. Of course the designer may make his own diagram for the number of ordinates he prefers to design with. In any case the run of the line for a few feet forward of the post will require special adjusting when the oxter is being faired.

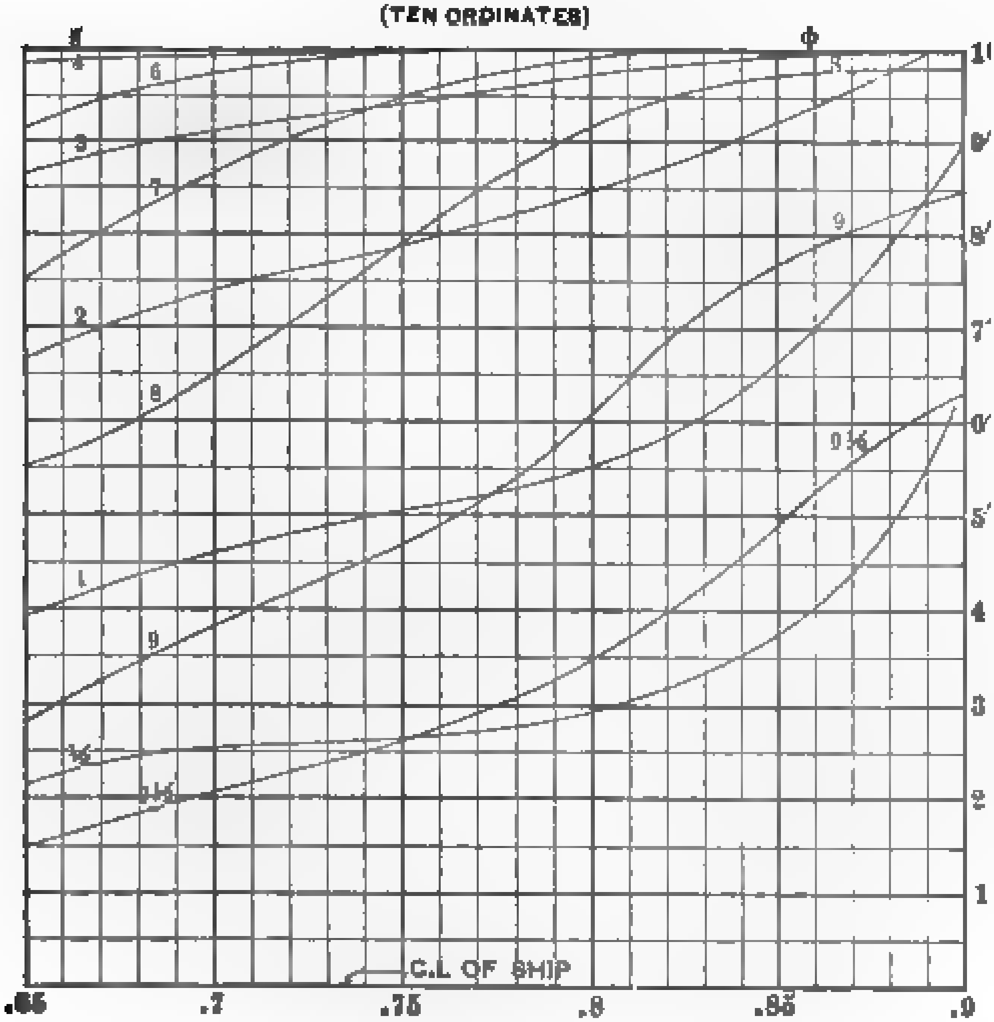
In addition to the diagram, the following table is given of actual load water lines of several types with the coefficients of area of same (a).

Load Line Half-Breadths Standardized.

Ordinates.	Fast Ocean Liner.	Freighter.	S.S. Yacht.	River Steamer.	Sailing Ship.	Steam Launch.	Oceanic.
"0"=A.P.	a =.726.	a =.857.	a =.683.	a =.717.	a =.797.	a =.656.	a =.771.
0	Post	Post	Post	Post	Post	Post	Post
½	.289	.448	.148	.382	.407	.275	.333
1	.531	.770	.479	.642	.678	.483	.631
2	.828	.980	.818	.884	.898	.750	.892
3	.945	1.000	.948	.977	.965	.900	.977
4	.988	1.000	.999	1.000	.992	.980	.995
5 =	1.000	1.000	1.000	.987	1.000	1.000	1.000
6	.976	1.000	.928	.932	.989	.900	.980
7	.881	1.000	.793	.791	.955	.760	.942
8	.670	.985	.578	.578	.830	.550	.775
9	.357	.781	.328	.308	.537	.303	.440
9½	.180	.464	.150	.154	.282	.182	.228
10	Stem	Stem	Stem	Stem	Stem	Stem	Stem

6th. The construction line for the bilge diagonal is variousl drawn from rise line or base line; but the latter is the more us ful, being adaptable to extremes of types and unaffected by ri of floor line; *i.e.*, the line should be drawn diagonally across tl

DIAGRAM OF BILGE DIAGONAL OFFSETS
FOR VARIOUS VALUES OF "b"
(TEN ORDINATES)



VALUES OF "b" (COEFF. OF B.D.)

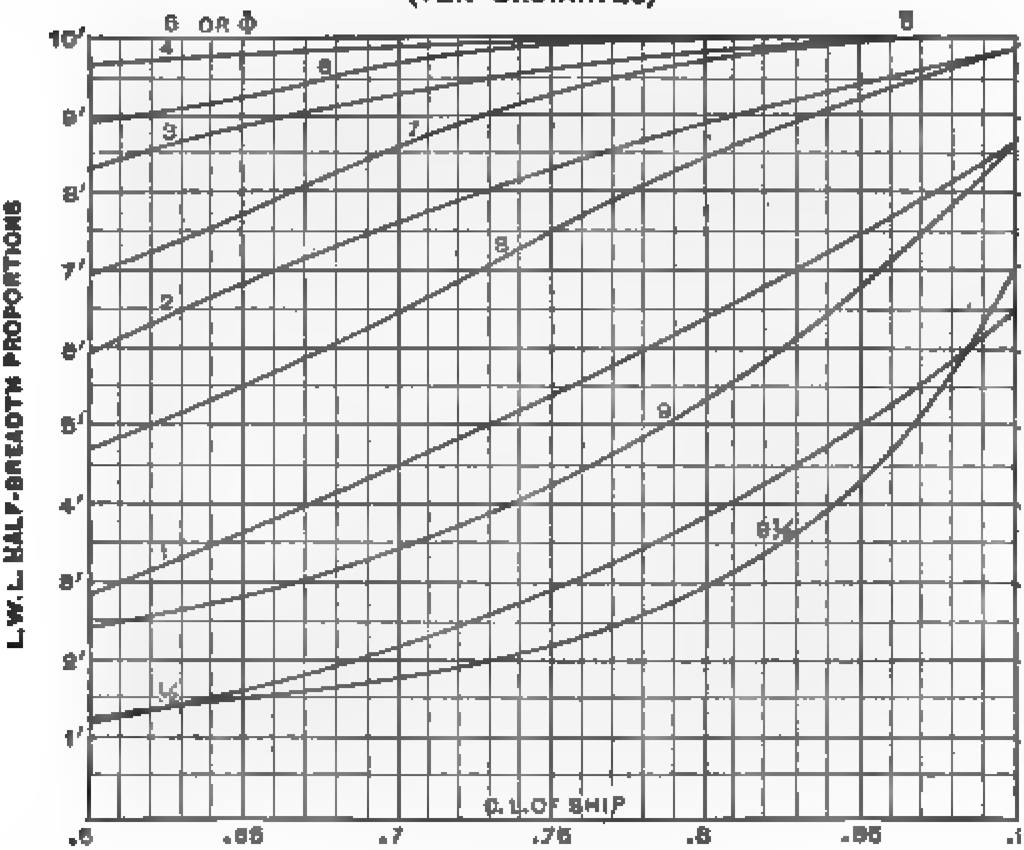
FIG. 13.

body plan from the intersection of the base with the half moulde breadth line to center line at load water line height. It is ev dent that the area enclosed by this line must bear a close relatio

ship to the prismatic coefficient which varies with p and is equal to $\frac{p}{.92}$ to $\frac{p}{.99}$ where p ranges from .60 to .82, respectively.

By determining the value of the bilge diagonal coefficient "b," and referring to the diagram opposite, the offsets for a line enclosing an equivalent area may be taken off and run as a half-breadth line.

DIAGRAM OF L. W. L. HALF-BREADTHS
FOR VARIOUS VALUES OF "α"
(TEN ORDINATES)



VALUES OF "α" (COEFF. OF L.W.L.)

FIG. 14.

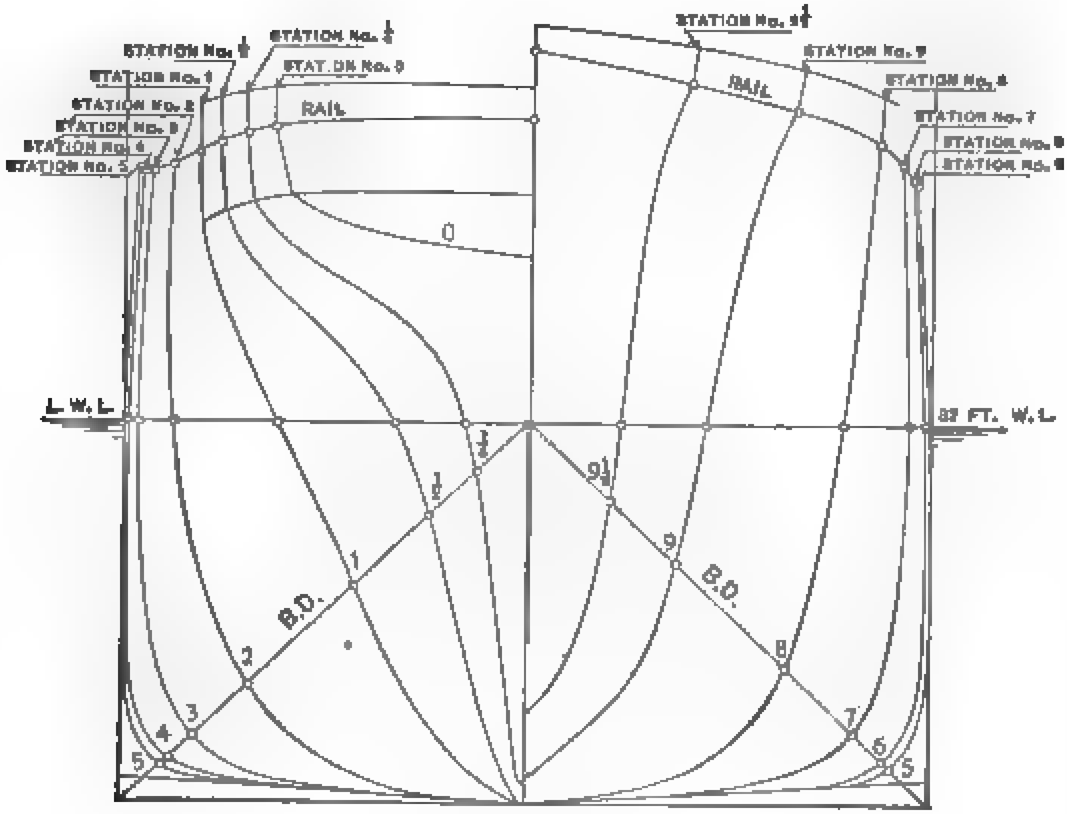
7th. The load water line and bilge diagonal half-breadths having been preliminarily faired, may be lifted off on a slip of paper and transferred to body plan construction lines, when there should be no difficulty in drawing in freehand the sections, having the "dead flat" section as one extreme guiding curve and the transom frame as the other.

8th. After the preceding sections have been carefully outlined

BODY PLAN OF "OCEANIC"

LENGTH B.P. [illegible], B. MLD. [illegible], D. MLD. [illegible].

SECTIONS [illegible] APT.



ELEMENT COEFFICIENTS

AREA OF MID. SECT.	β =	.[illegible]
BLOCK CO-EFF.	δ =	.[illegible]
PRISMATIC CO-EFF. . .	p =	.742
AREA OF L.W.L. . .	α =	.771
BILGE DIAGONAL	b =	.728
RELATION CO-EFF. . .	ε =	.[illegible]

Fig. 15.

to eye with the guide spots mentioned, the planimeter should be used to take a trial displacement, on the result of which will depend how near the designer's judgment has determined the true section line. In any case he cannot have got far away, and a very slight alteration (if any) is all that will be required.

9th. The sheer heights may now be taken from profile and spotted on body plan, level lines being struck across at these

heights on which to set off the rail half-breadths previously run i plan, as described in paragraph 4. This will enable the complete body plan to be drawn in approximately, from which spots ma be obtained to fair up.

Having got thus far, the final work of fairing will be a compara tively easy matter. A buttock line half-way out on the counte will prove a very useful line for this purpose, thereafter takin buttock and water line alternately until the whole body is faired Where great fairness is required, a complete set of diagonal line should be run; but ordinarily this is unnecessary, unless in smal craft where the sections are intended directly for the floor with out further fairing.

The following will prove a suitable method for designing an fairing the bossed plating enclosing after-end of shafting. Hav ing determined the outside diameter of the boss of spectacle frame lay off the distance to outer edge of boss barrel at forward end o same on the half-breadth plan, as at *A*. Then take another spo at the fore end of the stern tube equal to the siding of the vessel' bulkhead frame plus one inch clear of the stuffing box flange o the stern tube bulkhead at "*C*." Through these two spots con tinue a straight line until it intersects the water plane at the shaf center level "*D*." The angular space formed by the junction o

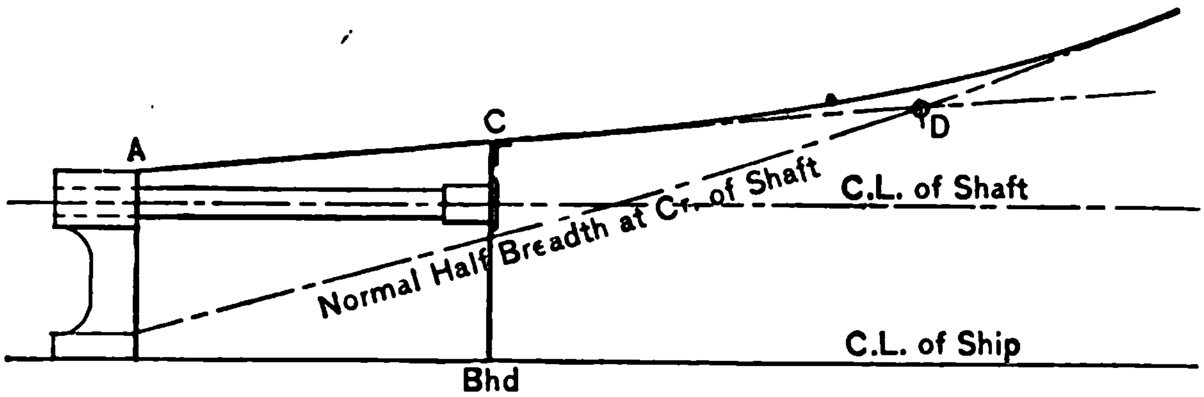


FIG. 16.

the water plane mentioned and the projected line should then b carefully faired into the eye with a spline, when the resulting lin will give you half-breadths at the shaft center height. These half breadths being transferred to the body plan, radii should be struc through them giving the contour of the bossing, which may b continued freehand into the frame sections above and below th boss, observing that the general tone harmonizes with the outlin of spectacle frame previously drawn in, in accordance with th form advocated under that heading.

Having outlined the form of bossing on body plan, three diago nal lines should be struck, the lower one intersecting the ar forming oxter under spectacle frame, the middle one through th

center of shaft, as shown to diagonal 1½, and the other making a like intersection with the curves of the slope, as shown on the diagram. These diagonals may now be lifted off and run in the

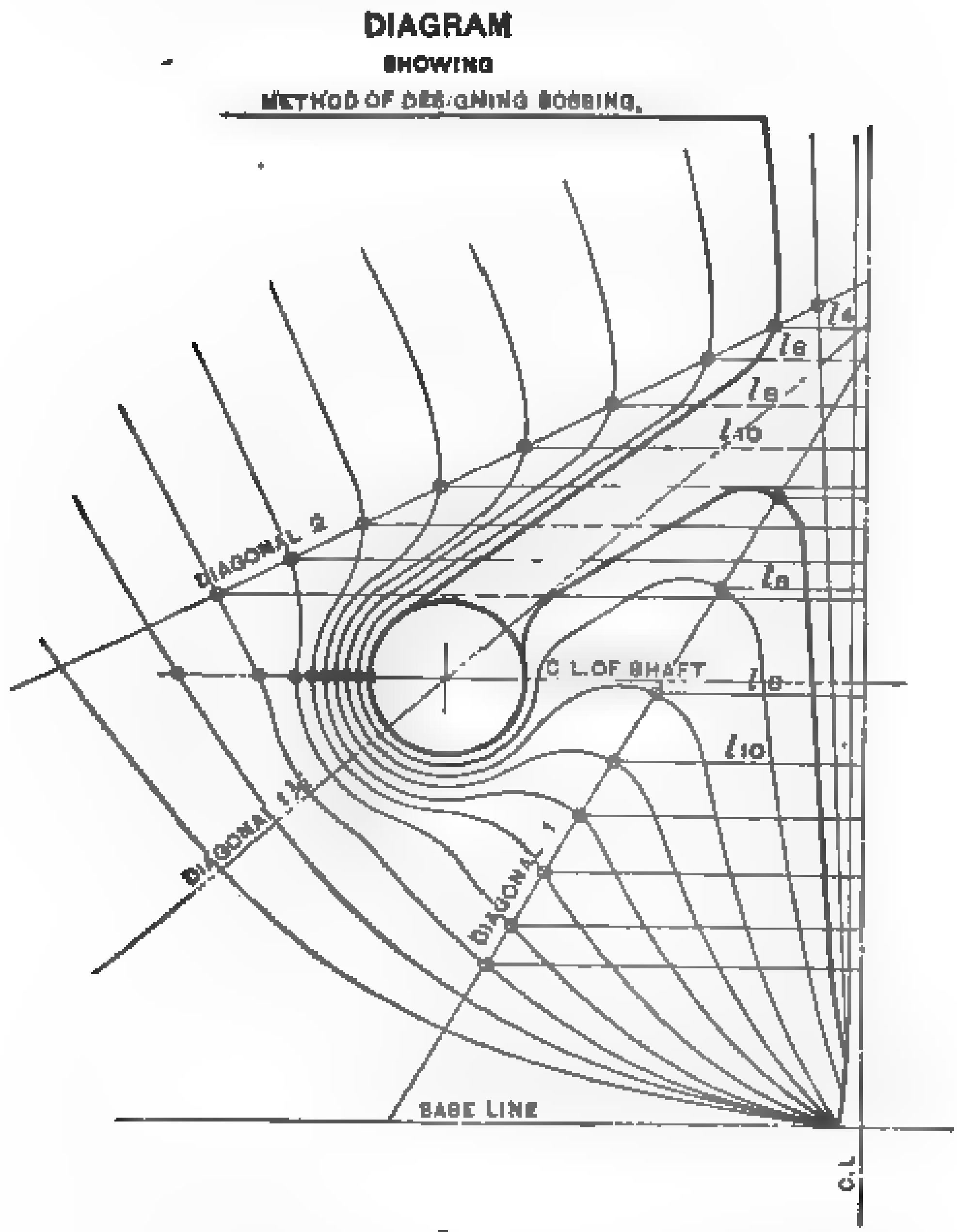


FIG. 17.

usual way on half-breadth, faired up, and retransferred to body plan, thus permitting of same being more accurately delineated, as it will be remembered these were originally drawn freehand.

Elements of

Piston Speed. Ft. per Min.	Class of Steamer.	Speed of Steamer in Knots.	Type of Propeller.	Type of Engine.
	Paddle.			
400	River paddle steamer	13-15	Side wheels feathering	Inclined
500	River paddle steamer	15-17	" "	"
600	River paddle steamer	18-22	" "	"
700	River paddle steamer	18-22	" "	"
700	Sea paddle steamer, heavier paddle wheels required . .	18-22	" "	"
	Cargo.			
530	Ordinary freight, 300 to 450 . .	8-11	Single screw	Inverted
530	Ordinary freight, 300 to 450 . .	11-13	" "	"
600	Ordinary freight, 300 to 450 . .	11-13	Twin screw	"
600	Ordinary freight, 300 to 450 . .	11-13	" "	"
	Cargo and Passenger.			
700	Intermediate steamships, 450-600	13-16	Single screw	Inverted
750	Very large intermediate, cargo and passenger, 600 and over	14-16	Twin screw	"
	Ocean Liners.			
800	Passengers and mail	16-19	Single screw	Inverted
800	Passengers and mail	16-19	Twin screw	"
950	Passengers and mail	19-23	" "	"
950	Passengers and mail	19-23	" "	"
950	Passengers and mail	19-23	" "	"
800-910	Fast channel & sound steamers	19-23	Twin screw	Inverted
950	Battleships & cruisers, 1st class	23	Twin screw	Inverted
950	Battleships & cruisers, 1st class	23	" "	"
950	Battleships & cruisers, 1st class	23	" "	"
1,200	Torpedo-boat destroyers and scouts	30	Twin screw	Inverted
	Turbine-driven Vessels			
5,700	Turbine river steamer and turbine steam yachts	16-23	Multiple screw	Hor Comp.
6,000	Turbine-driven Atlantic liner, passenger and mail . . .	22	" "	" "
6,200	Turbine-driven pass. and mail channel and sound steamers	25	" "	" "
7,000	Turbine-driven torpedo-boat destroyer and scout . . .	30	" "	" "
10,000	Turbine-driven torpedo-boat destroyer and scout . . .	36	" "	" "
8,000	Small 44-ton displacement experimental vessel, low coal radius	32	" "	Hor. Triple

* By permission of

Marine Engines.*

Machinery Particulars.						I.H.P. per Ton of Eng. Boilers and Water.
Number of Cylinders in Each Engine.	Cylinder Ratios.	Type of Boilers.	Boiler Press. Lbs.	Boiler Draft.		
2-Comp. Side by side	1 to 3.5	Cyl.	100	Nat.	. .	6.50
" "	" "	"	110	Forced	. .	7.22
" "	" "	Loco.	120	"	. .	11.00
3-Triple Side by side	1 : 2.16 : 4.82	Cyl.	160	"	. .	10.00
" "	" " "	"	"	"	. .	9.00
3-Triple	1 : 2.65 : 7.1	Cyl.	175	Nat.	. .	4.85
" "	" " "	"	200	Forced	. .	6.00
" "	" " "	"	"	"	. .	5.85
4-Quad.	1 : 2.1 : 4.5 : 9.14	. . .	214	"	. .	5.45
3-Triple	1 : 2.65 : 7.1	Cyl.	200	Nat.	. .	5.12
4-Quad.	1 : 2.07 : 4.24 : 8.82	"	214	Assist.	. .	4.37
3 or 4-Triple	1 : 2.65 : 6.38	Cyl.	180	Nat.	. .	7.00
" "	" " "	"	"	Forced	. .	6.00
4-Triple	1 : 2.07 : 6.37	"	"	Nat.	. .	6.16
6-Quad.	1 : 2.08 : 4.16 : 8.71	"	220	"	. .	5.95
6–8 Quad.	" " "	"	"	Forced	. .	6.25
4-Triple	1 : 2.28 : 5.84	Cyl.	180	Forced	. .	8.00–9.70
4-Triple	1 : 2.26 : 7.00	Cyl.	175	Nat.	. .	8.50
" "	" " "	"	"	Forced	. .	10.00
" "	" " "	W. Tube	250	Nat.	. .	12.00
4-Triple	1 : 2.36 : 5.50	Yarrow W. Tube	250	Forced	. .	41.00
	No Expansions.					
Parson's Turbine	125	Cyl.	150	Forced	. .	12.00
" "	135	W. Tube	180	"	Super-heated steam	16.00
" "	125	"	170	"	. .	20.00
" "	"	"	"	"	. .	55.00
" "	"	"	"	"	. .	70.00
" "	150	"	150	"	. .	100.00

J. Calder, B.Sc.

Level lines as shown at l_2, l_4, l_6, etc., are now drawn from the point of intersection of frame with diagonals 1 and 2, and the half-breadths taken off at these levels and finally faired-up on half-breadth, when it will be found that the resulting horizontal ribband line, besides acting as a check on the fairness of the diagonals, will show the "wind" of the shell plating wrapping into oxter and body post and insuring a natural "snye" without any chance of "gather" or unfairness.

The oxter underneath the ship's counter may be faired in a similar manner.

Engine Room Lengths.

Length of Engine Space.	Size of Engines.	Length of Engine Space.	Size of Engines.	Length of Engine Space.	Size of Engines.
8′ 6″	10″ & 20″ / 10″ T.	22′ 0″	19″, 31″, 54″ / 42″	32′ 0″	24½″, 34½″, 49½″, 70″ / 36″
10 6	22 & 40 / 27	23 0	27, 40, 65 / 36	34 0	32⅛, 59, 92 / 42
12 9	17 & 26 / 20 T.	24 0	19½, 28, 39, 57 / 36 T.	34 0	24, 34, 48, 68 / 42 T.
12 3	15 & 30 / 21 T.	24 0	30, 45, 70 / 54	35 0	32½, 59, 92 / 54
13 6	11, 17, 17 / 11	26 0	28, 46, 75 / 48	35 0	40, 66, 106 / 72
14 0	10, 16, 26 / 21	26 0	22, 36, 59 / 42	36 0	32, 52, 60, 60 / 42
16 0	23 & 46 / 36	26 0	25, 41½, 68 / 42	39 7	29, 46, 72 / 48 T.
16 6	13½, 22½, 36 / 24 T.	26 0	23½, 39, 65 / 42	40 0	31, 43, 60, 86 / 54
17 0	19, 30, 50 / 30	26 0	22, 35, 59 / 62	40 0	33½, 51, 78 / 48 T.
18 0	18, 28, 45 / 30	26 6	30, 50, 80 / 54	42 0	34¾, 53, 63, 63 / 48 T.
18 4	21½, 31, 34, 34 / 20	27 0	28, 46, 75 / 48	45 0	30, 43, 63, 89 / 60 T.
20 0	21, 34, 56 / 40	27 6	25, 42½, 72 / 48 T.	47 6	32, 45½, 66, 66, 66 / 54
20 0	18, 27, 42 / 24	27 6	31, 52, 83 / 54	48 0	35, 50, 70, 100 / 66 T.
20 0	18½, 27, 42 / 18 T.	27 6	25, 42½, 72 / 48	48 0	28½, 28½, 55, 77, 77, 77 / 60
20 0	21, 34, 59 / 36	28 0	28, 46, 76 / 48	48 0	43, 69, 79 / 60
21 0	17, 26½, 40 / 24 T.	28 0	29, 45, 74 / 48	59 0	40½, 55, 77, 77, 77 / 60
21 0	24, 40, 63 / 42	28 0	32, 52, 81 / 54	60 0	40½, 55, 77, 77, 77 / 54
22 0	22, 36, 57 / 36 T.	28 0	30, 50, 80 / 54	62 6	35¾, 50¼, 73½, 105 / 69
22 0	19, 32, 52 / 36	28 2	19, 28½, 41, 60 / 42 T.	74 0	49½, 73, 95, 95, 95 / 60
22 0	23½, 38, 62 / 36	28 3	19½, 28¾, 30¾, 30¾ / 18 T.	77 6	37, 37, 79, 98, 98 / 69 T.
22 0	24, 38, 62 / 36	. . .	. . . . . .	. . .	. . . .

Twin sets noted with "T."

CHAPTER III.

THE PREPARATION OF SPECIFICATIONS.

Too much care cannot be expended in the drafting of the hull specification. Clearness and conciseness should be aimed at consistent with an embodiment of all details of hull, fittings, and outfits supposed to be supplied, and all repetition or ambiguity of phraseology carefully avoided. Hampering restrictions should be left out. Know your requirements and state them distinctly. As in all other ship construction work, it will pay to have a definite routine or system in which to draft the specification. Of course, it is obviously impossible to have a standard specification which shall apply to all ships, as vessels are so diverse in their types, design, construction, and equipment as to make this an impossibility. But by keeping a routine list of headings of paragraphs before one, and taking these in rotation when drafting the clauses, the liability to omit important requirements is reduced to a minimum, besides the saving in time and distraction of thoughts through having to recollect what comes next. For this purpose the following headings have been selected which will apply to ordinary vessels. Of course, for special types these will require modifications and additions which will suggest themselves.

Specification Headings.

Title giving type of vessel.

1. *Dimensions*, moulded length, breadth and depth, depth of hold, load draft and deadweight.
2. *Classification.* The Government laws to which the vessel and her equipment are to conform, also full particulars of the class she is to take at the Classification Society concerned.
3. *General Description.* Type of stem and stern, number of decks, laid or otherwise, length and character of erections, number of masts. Number of passengers, description of housing of passengers, officers, and crew. Nature of cargo and handling appliances. Location of machinery, and any special features of the vessel.
4. Material of hull and rivets.
5. Keel, and centre girder in double bottom ships.
6. Bilge or side fenders and mouldings, docking keels.
7. Stem.
8. Stern frame.

9. Shaft brackets.
10. Rudder and stock (also trunk and bearing).
11. Shell plating.
12. Inner bottom, including plating, side girders, floors and margin plate.
13. Scantling in machinery space.
14. Peak tanks.
15. Deep tanks.
16. F. W. storage tanks.
17. Steel decks and flats.
18. Transverse bulkheads.
19. Longitudinal bulkheads.
20. Bunkers, oil or coal.
21. Engine and boiler casings.
22. Shaft tunnels.
23. Oil trunks, expansion.
24. Centre keelson } in single-bottomed ships.
25. Side keelsons } in single-bottomed ships.
26. Hold and 'tween deck stringers.
27. Panting arrangements.
28. Frames and reverse frames, in double bottom, up sides and at ends.
29. *Floors*, throughout in single-bottomed ships, at ends and tail brackets in double bottom ships, also reference to No. 12.
30. Web frames.
31. Deck beams and knee brackets.
32. Stanchions to beams.
33. Strong beams in E. and B. space.
34. Hatchways and coamings, in oil or cargo spaces, covers, fore and afters, bearers, etc.
35. Cargo and coal ports.
36. Grain trimming hatches.
37. Chain lockers.
38. *Machinery Foundations;* main, auxiliary and deck machinery, also boiler saddles and shaft and thrust bearing seats.
39. Sheet steel bulkheads.
40. Steel deck houses, other than erections.
41. Bridges, navigating or docking.
42. Steel masts.
43. Steel kingposts.
44. Steel derricks, spars, etc.
45. Wood masts, kingposts and spars.
46. Wood decks.
47. Wood deck houses.
48. Ceiling and sparring.
49. Boat stowage.
50. Anchor stowage.
51. Watertight doors and scuttles.

General description of joiner work, including entrances and stairways:

52. In passengers' quarters.
53. In officers' quarters.
54. In crew's quarters.
55. Pantry accommodations.
56. Galley accommodations.
57. Ice room.
58. Sidelights and decklights; also borrowed lights.
59. Cattle fittings.
60. Hawse pipes.
61. Bollards and fairleads.
62. Hold ladders.
63. Ladders to erections and bridges.
64. *Davits*, boat and anchor, also provision or coaling davits.
65. Rails, bulwarks, also rail and awning stanchions.
66. Standing and running rigging, including cargo boom handling gear.

67. Sails, covers, and awnings.
68. Cement and tiling.
69. Paint work.
70. Heating system.
71. Lighting system.
72. Ventilating.
72*a*. Refrigerating system.
73. *Deck Machinery*, including windlass, winches and capstan, also steam and exhaust piping.
74. Fresh and salt water service.
75. Fire, pumping and draining system.
75*a*. Cargo oil system.
76. Scuppers, from all exposed houses, etc., and from sanitary quarters.
77. Engine room and docking telegraphs.
77*a*. Steering gear.
78. Anchors, chains, and line outfit.
79. Boats and outfits.
80. Flags, etc.
81. Hose, fire and wash deck, also fire buckets.
82. Oil tanks, for lamps, etc.
83. Steaming lights.
84. Lamps and lanterns, also rockets, etc.
85. Navigating instruments.
86. Boatswain's stores.
87. Carpenter's stores.
88. Cargo handling gear, slings, hooks, etc.
89. Cook's or galley outfit.
90. Cabin outfit.
91. Cutlery outfit.
92. Crockery and glass.
93. Table linen.
94. Bed linen and bedding.
95. Spare glasses for side-lights in passenger ships.
96. Galvanizing.
97. Trim and stability.
98. Plans to be furnished owners.
    Capacity and deadweight.
    General arrangement.
    Cabin booking plans.
    Piping plans.
    Stability curves and information.
99. Docking.
100. Trial trips.
101. Inspection fees (class, etc).
102. *General clause* relating to material, workmanship, inspection by owners, alterations, extras, etc.

Flags.

National colors.
House flags, and burgee with name.
International signal code.

Boat Outfit.

Ash oars, thole pins or rowlocks.
Rudder (lanyard).
Tiller (lanyard).
Painter, 5 fathom line.
Cable, 20 fathom line.
Boat hook.
Water breakers.
Bread tank.
Plugs for bung hole; 2, with chain.
One anchor.
One sea anchor.
One bailer.
One mast yard and sail.
One compass 4″ card in case.
Four oil lanterns to burn 8 hours.
Four oil distributers, 1 gallon each.
Twelve boat hatchets.

Boatswain's Stores.

Watch tackles.
Relieving tackles.
Luff tackles.
Spare blocks, double and single, assorted.
Spare sheaves, for boat falls.
Snatch blocks.
Cargo gins.
Deck scrubbers.
Wood fenders, with lanyards.
Cork fenders, with lanyards.
Marline spikes.
Crowbars.
Chain hooks.
Chain slings.
Hair crate hooks.
Screw shackles.
Pairs of grip-hooks.
Pairs of case-hooks.
Coir brooms and handles.
Mops.
Ballast shovels.
Scrapers, triangular.
Scrapers, steel file.
Set of funnel blocks and boards.
Boatswain's chairs, one to each mast.
Pilot ladder.
Five-inch portable fire engine pump with hose.
Bath bricks.
Hand spikes.
Paint scrubbers.
Pairs of handcuffs.
Branding iron.
Paint brushes, assorted.
Paint pots, one-half gallon.
Squeegees, large.
Scraping box, tin.
Sewing palms.
Needles.
Beam clamps.
Whitewash brushes.

Carpenter's stores.

"Propeller" notice boards.
"Smoking" notice boards.
"No admittance" notice boards.
Pump hook, jointed.
Chain punches.
Pitch pot, 3 gals. and ladle.
Tar bucket.
Grindstone and trough, 18″ diam.
Shifting spanner, large.
Ring spanners, to fit bunker plates, etc.
Keys for cargo ports.
" " sidelights.
" " coal ports.
" " mushroom ventilators.
Rim spanner for sidelights.
Spanners for deep tank hatch bolts.
Rail straightener, 3′ 6″ long.
Rod sounding rods.
Flexible sounding rods, 2′ 0″ long.
Caulking tools.
Caulking mallet.
Spare hatch wedges.
Capstan bars and rack.
Monkey wrench.
Wheel-house axes, large.
Tools in chest, with ship's name on; chest and tools.
One 26″ hand saw.
One crosscut.
One auger 1½″.
One purger 1¼″.
One adze.
One hammer.
Two top mawls.
Two screwdrivers.
One jack plane.
One hand plane.
Three chisels, assorted.
Three gimlets, assorted.

Steaming Lights.

Two masthead / Port / Starboard } lamps, brass, for electric

do. do. galvanized iron, for oil.

Two riding lights / One overtaking light / Three ruby lights } oil.

Three black balls.

Spare glasses for lamps, 2 for each.

Carriers and halliards for masthead and riding lights.

Lamps and lanterns.

"Exit" lamps in passengers' quarters.

Dark lanterns (3 for large ships).

Cargo lanterns (12 for large ships).

White lanterns (2 for large ships).

Hurricane lights (5 for large ships) with 3 spare glasses.

Lamps for saloon and officers' rooms in small ships.

Lamp scissors.

Oil funnels.

Lamp wicks.

Rockets, signal cannon, to be supplied as required by U. S. laws, together with owner's night signals, etc.

Navigating Instruments.

Standard compass and stand.

Ten inch spirit compasses in navigating positions.

One spare card.

Boat's compasses, 4" card.

Sounding machine, or deep sea lead (28 lbs.), line and reel. 180 fathoms.

Hand lead (16 lbs.), line, and reel, 30 fathoms.

Pelorus.

Clocks.

Aneroid barometers.

Telescope.

Binoculars, marine.

Log slates.

Parallel ruler.

Pair dividers.

Chart weights.

Foghorn.

Tarpaulins.

Usually 3 to each weather deck hatch; 1 to others.

One rubber sheet to hatches on which cattle are carried.

Covers to all sails and instruments, wheels, etc., in exposed positions; weather cloths to shelter passenger decks in large passenger ships.

Bakery Outfit.

Two biscuit tubes.

One biscuit forcer.

One apple corer.

One bread rasp.

One galvanized bucket.

One buckwheat jug.

Six cake hoops.

One hundred and twenty corn bread tins.

One dough knife.

One scraper.

One sugar dredger.

One flour dredger.

Two flour scoops.

One tin opener.

One casserole mould.

Eighteen (quart) jelly moulds.

Six pudding moulds with lids.

Seventy-two muffin rings.

One bread grater.

One nutmeg grater.
One barm can.
One palette knife.
Two sets cutlet paste cutters.
Six paste brushes.
Two rolling pins.
One set of scales, ¼ oz. to 14 lbs.
One flour sieve.
One spice box complete.
Twelve bread tins.
Two French roll tins.
Twenty-four open tart tins.
One hundred and forty-four patty tins.
Six rice pudding tins.
Six roll tins.
Eighteen sandwich bread tins, with lids.
Twenty-four sponge cake frames.
One water can.
Two egg whisks.
One set icing pipes.
One icing bag.
One enameled whisking bowl.
One patent egg whisk.
One egg basket.
One suet machine.
One bread knife.
Twelve large bread sheets.
One bread prover, galvanized iron, 6′ 0″ × 2′ 5″ × 1′ 5″ with copper steam pipe.

Galley Outfit.

Braising pans, copper, with wire nets.
Water cans.
Butcher's choppers.
Cook's saws.
Tin colanders.
Chopping block.
Dippers, tin.
Aluminum stew pans, with handles and lid.
Sauce pans (enameled iron), 1 qt., 3 pt., and 2 qt.
Oval fish kettle and lid.
Potato masher.
Dog baskets, wicker, tin lined.
Sieves, hair mesh.
Sieves, wire mesh.
Sauce ladles, small.
Tin opener.
Beef press.
Pea soup masher, tammy sieve.
Copper stew pans, 6″–16″ diam., with long handles, and lids with long handles.
Stock bucket.
Stock pot.
Omelette pans, copper.
Frying pans, round.
Frying pans, oval.
Tormentors.
Pokers.
Shovels.
Rakes.
Gridirons, double.
Gridirons, large.
Sets of skewers, assorted sizes.
Egg basket.
Glaze pot, copper and brush.
Four-inch basket ladle, wire.
Frying baskets, round, wire.
Cook's forks.
Salt box.
Flour box.
Wire gravy strainer.
Grill tins.
Two gallon copper kettle.
Jelly bag.
Knives, French.
Knives, butcher's.
Knives, mincing.
Knives, oyster.
Knives, palette.
Knives, potato.
Bill of fare frame.
Pie pans, 12″ × 8″, enameled.
Pie pans, 8″ × 6″.

Steak tongs.
Store tins.
Stove top hooks.
Porridge whisks, strong wire.
Cutlet bat.
Vegetable cutters.
Vegetable scoops.
Brawn moulds.
Tongue press.
Pepper dredgers.
Hot pot tins.
Plate carriers.
Bread grater.
Flour dredge.
Iron ladles.
Larding needles.
Trussing needles.
Potato masher.
Egg slicer.
Fish slicer.
Spoons, iron.
Spoons, wood.
Steel.

Ship's Galley Outfit.

Mess kids, large, small and oval.
Square steamers.
One square coffee boiler (28 gal.) B. T.
Oval boilers (15 gal.) B. T.
Roast tins.
Saucepans, iron enameled.
One round steam boiler (50 gal.) cast iron with large brass tap.
Range.
Colanders.
Shovel.
Poker.
Buckets, galvanized iron.
Rake.
Tormentor.
Large ladle.
Square duff tins.
Chopping block.

Pantry Outfit.

Pair butter spades.
Meat choppers.
Poultry choppers.
One clock.
Dish covers, B. M.
Egg slicers.
Ice pricker.
Jugs (enameled), 1 gallon.
Two bread knives.
Two carving knives.
Two French knives.
Two ham knives.
Pairs knives and forks for poultry.
Plate covers, tin.
Iron spoons, 18″ long.
Lemon squeezer.
Tin openers.
Slop receivers, 20 gallons.
Soup ladles.
Soup tureens, B. T.
Steel.
Waiter's carpathian.
Wire whisks 12″-18″.
Milk cans with lid and spout, 2 gallons.
Steam carving table 6′ 0″ × 2′ 6″, with tin top, 3 large, 2 medium and 2 small wells.
Steam egg boiler.
Steam bain-marie, 4 stew pans, brass frame.
One coffee boiler, 10 gallons, E. P.
One hot water boiler, 15 gallons E. P.
Whisking bowl.
Water cooler.

Electroplate and Cutlery.

Asparagus tongs.
Butter coolers.
Cheese scoops.

Tea pots, 3 pints.
Tea pots, $1\frac{1}{2}$ pints.
Coffee pots, 2 pints.
Coffee pots, 1 pint.
Entree dishes, 10″ oval.
Entree dish covers, with movable handles.
Vegetable dishes.
Vegetable dish covers, with movable handles.
Ice tongs.
Sauce frames (Worcestershire, etc.).
Prs. fish carvers.
Fish forks.
Fruit forks.
Dessert forks.
Pickle forks.
Butter knives.
Fish knives. -
Dessert spoons.
Soup spoons.
Sauce ladles.
Soup ladles.
Finger bowls.
Ice pails.
Napkin rings, numbered.
Prs. nut crackers.
Toast racks, large.
Toast racks, small.
Fruit knives.
Mustard spoons.
Salt spoons.
Tea spoons.
Egg spoons.
Table spoons.
Sugar bowls, large.
" bowls, small.
" tongs, small.
" tongs, large.
Sardine tongs.
Cream jugs, large.
Cream jugs, small.
Fine sugar sifters, gilt bowls.
Fine sugar bowls.
Syrup jugs, hinged lids.
Hot water jugs, 1 pint.
Tureen and covers for soup, 6 quarts.
Tureen and covers for sauce.
Fruit dishes, gilt, large 12″ long.
Fruit dishes, gilt, small, $9\frac{1}{2}$″ long.
Wine corks.
Waiters, 8″, 10″, 12″.
Wine funnel.

Glass.

Celery glasses.
Tumblers.
Soda glasses.
Champagne glasses.
Claret glasses.
Liqueur glasses.
Port and Sherry glasses.
Cocktail glasses.
Bedroom tumblers.
Pickle jars.
Glass dishes, small oval.
" " large oval.
" " large round.
" " small round.
" " ground glass for ice cream.
Water decanters, saloon.
Water decanters, bedroom.
Salt casters.
Pepper casters, E. P. tops.
Red pepper casters, E. P. tops.
Salad bowls.

China.

Dessert plates.
Tea cups, afternoon.
Tea saucers, afternoon.

Earthenware.

Breakfast cups and saucers.
Tea cups and saucers.
After-dinner coffee cups and saucers.

Egg cups, d. e.
Dinner plates.
Soup plates.
Cheese plates.
Slop basins.
Jardinières, large.
Jardinières, small.
Chambers, bedroom.
Milk jugs.

Linen.

Two prs. sheets to each berth.
One pr. blankets to each berth.
One bed-spread to each berth.
Two pillow cases to each pillow.
Two pillows to each berth.
One mattress, over spring mattress.
One mattress cover.
Three sets tablecloths.
Napkins.
Table covers, baize, red, etc.
Glass cloths.
Towels, pantry.
" passenger, four to each.
" officers, four to each.
" lavatories.
Towels, bath.
Dusters.
Covers for saloon chairs and settees.

General Stores.

Spring balance.
Scales and weights.
Handy billy.
Brooms.
Brushes, banister.
Dustpans and brushes.
Shoe brushes.
Buckets.
Mops.
Cuspidores and linings.
Dinner bell.
Cork screws.
Knife board.
Table gong.
Deck chairs.
Wicker chairs.
Blotting pads.
Bibles, etc.
Chess men, etc.
Library books.
Printing press.

CHAPTER IV.

FREEBOARD.

In the following tables the word Freeboard denotes the height of the side of a ship above the waterline at the middle of her length, measured from the top of the deck at the side, or, in cases where a waterway is fitted, from the curved line of the top of the deck continued through to the side. The freeboards and the corresponding percentages of reserve buoyancy necessary for flush-deck steamers not having spar or awning decks and for flush-deck sailing vessels are given in Tables *A* and *D* for vessels of these classes and of various dimensions and proportions. The freeboards necessary for spar- and awning-deck steamers are given in Tables *B* and *C*. The latter are determined by considerations of structural strength, and they denote the limitations to depth of loading which are thereby imposed upon first-class vessels of these types. The freeboards and percentages of reserve buoyancy thus obtained being in excess of what would otherwise be required, the amount of such percentages are not given in Tables *B* and *C*.

The exact freeboard required for a given ship of standard proportions belonging to either of the classes comprised in Tables *A* and *D* may be calculated by constructing a displacement scale to the height of the deck to which the freeboard is measured, so as to give the whole external volume up to the upper surface of that deck. The percentage of the total volume which is given in the tables as the reserve buoyancy for a vessel of given type and dimensions will be the amount of volume that must be left out of the water. If a waterline be drawn up upon the displacement scale aforesaid to cut off the given percentage of total volume, the height of side above this line will be the freeboard required.

In order to simplify and reduce the work that would be involved by the above mode of determining the waterline and the consequent freeboard that correspond to a given percentage of reserve buoyancy, an approximate method is adopted in the following tables, which enables the freeboard of a vessel to be calculated with a sufficient degree of accuracy for all ordinary working purposes. The use of this method not only saves the time and labor that would be involved by making a complete displacement scale for the whole external volume of the ship, but, what is much more important, it makes the tables easily and directly applicable in cases where such a displacement

scale for a vessel is not at hand, or where the data requisite for constructing one are not procurable.

In this approximate method the form of the ship is taken into account by means of proportionate quantities, which are termed coefficients of fineness, instead of by the exact volumes that a displacement scale would give. It is found that the whole internal volume of a ship as measured for register tonnage divided by the product of the length, breadth, and depth, measured as described in the following clauses, 1, 2, and 3, gives a fractional quantity of coefficient which bears a nearly constant relation to the quantity that would be obtained by dividing the whole external volume below the upper surface of the deck by the product of the length, breadth, and depth. This fractional quantity is called the "coefficient of fineness" for freeboard purposes, and it serves the same practical object, when combined with the dimensions of the ship in the manner explained in the tables, as the volume itself would do.

In applying such an approximate method as the above, it is necessary to connect the coefficients of fineness given in the tables with a standard sheer and round of beam. The standard scales for sheer and round of beam that have been adapted for this purpose are given in Clauses 18 and 19 hereafter. Descriptions are also there given of the corrections that should be made for deviations from these standard amounts.

The freeboards given in the tables are for flush-deck vessels in all cases. Such reductions in freeboard as may be allowed for deck erections of various kinds and sizes in steamers not having spar or awning decks and in sailing vessels are described in paragraphs 11, 12, 13, 14, 15, 16, and 17.

No reduction of freeboard should be allowed on account of deck erections in spar-deck and awning-deck steamers, except in spar-deck vessels in which an allowance may be made for a long bridge house, see pp. 21 and 22.

Tables *A* and *D* give the minimum freeboards for first-class iron and steel vessels, the strength of which is at least equal to the requirements of the 100a class in Lloyd's Register for three-deck and smaller vessels. The freeboard of all other iron and steel vessels, classed or unclassed, should be regulated by the same standard, the increase of freeboard required in each case being determined by the limit at which the stress per square inch upon the material of the hull amidships shall not exceed that of the standard class, of the same proportions, form, and moulded depth, when loaded to the freeboards required by Tables *A* and *D*. Tables *B* and *C* give the freeboards for vessels built in accordance with, or equal to, the requirements of Lloyd's Register for the spar- and awning-deck classes, and are

subject to the conditions just stated for any modifications of strength in excess of diminution of the requirements of their respective classes.

1. Length. — The length of the vessel is measured on the load line from the fore side of the stem to the aft side of the sternpost in sailing vessels, and to the aft side of the aft post in steamers.

2. Breadth. — The breadth used in obtaining the coefficient of fineness is the extreme breadth measured to the outside of plank or plating as given on the certificate of the Ship's Registry.

3. Depth of Hold. — The depth used in obtaining the coefficient of fineness is the depth of hold as given on the Certificate of the Ship's Registry. This dimension is subject to modification in determining the coefficient of fineness as explained in Clause 4.

4. Coefficient of Fineness. — The coefficient of fineness in one-, two-, and three-deck and spar-deck vessels is found by dividing 100 times the gross registered tonnage of the vessel below the upper deck by the product of the length, breadth, and depth of hold. In awning-deck vessels the registered depth and tonnage are taken below the main deck.

(a) It is of importance in the application of the rules and tables of freeboard that the coefficient of fineness deduced from the under-deck tonnage and the principal dimensions to be a correct index to the vessel's relative fullness of form, and that a change in any of those elements which affect the coefficient, determined in accordance with the rule set forth, should be considered, and the necessary correction, having regard to the special circumstances of the case, introduced. Among the cases that have from time to time come under notice are the following:

(b) *Vessel Having a Cellular Bottom Throughout, or Floors of Greater Depth than those Usually Fitted.* — In such a case the coefficient as determined from the under-deck tonnage is in most instances slightly greater than it would be if the vessel were framed on the ordinary transverse system with floors of the usual depth. No general rule can be given for guidance, but it is not difficult, if the depth and slope of the top of the cellular bottom or floor be compared on the midship section with the depth and slope of an ordinary floor, to determine very closely the amount of the correction necessary.

(c) *Vessel Constructed with Floors of the Ordinary Kind, but with a Cellular Bottom for a part of the Length Amidships Under*

the Engines and Boilers. — In such case the registered under-deck tonnage is smaller than it would be if the vessel were framed with ordinary floors throughout, the difference being the tonnage of the space between the bottom of the cellular bottom in the part amidships and the level of the ordinary floor. The depth of hold is also measured by the customs officials to the top of the cellular bottom, and this depth is inserted in the register. Under such circumstances, in order to arrive at the coefficient of fineness the vessel would have, if built on the ordinary system throughout and for which the tables are framed, the tonnage of the volume between the top of the cellular bottom and the level of the ordinary floor should be calculated and added to the registered under-deck tonnage. The tonnage so corrected used in conjunction with the depth of hold to the top of the ordinary floor, gives the coefficient to be used in the tables.

(*d*) *Vessel Constructed with a Cellular Bottom Throughout the the Fore and After Holds, but with Floors of the Ordinary Kind Fitted for a Part of the Length Amidships Under the Engines and Boilers.* — In such a case the tonnage of the space between the top of the ordinary floors in the part amidships and the top of the cellular bottom, if made continuous, should be estimated and deducted from the registered under-deck tonnage and the remainder employed in conjunction with the depth of hold to the top of the cellular bottom in determining the coefficient of fineness.

(*e*) Other cases may in practice arise in which the registered under-deck tonnage, or the registered depth of hold, or registered breadth require modification before being used in the determination of the coefficient of fineness, but little difficulty will be experienced in making the necessary correction if it be remembered that the coefficient sought is the coefficient the vessel would have if framed on the ordinary transverse system.

5. Moulded Depth. — The moulded depth of an iron or steel vessel, as given in the tables, is the perpendicular depth taken from the top of the upper deck beam at side, at the middle of the length of the vessel, to the top of the keel and the bottom of the frame at the middle line, except in spar- and awning-deck vessels, in which the depth is measured from the top of the main-deck beams. In wooden and composite vessels the moulded depth is taken to be the perpendicular depth from the top of the upper-deck beam at the side of the vessel amidships to the lower edge of the rabbet at the keel.

(*a*) The form at the lower part of the midship transverse section of many wooden and composite vessels being of a hollow

character, as in cases where thick garboard strakes are fitted, the moulded depth in such instances should be measured from the point where the line of the flat of the bottom continued cuts the keel.

6. Freeboard. — The moulded depth, taken as above described, is that used in the tables for ascertaining the amount of reserve buoyancy and corresponding freeboard in vessels having a wood deck, and the freeboard is measured from the top of the wood deck at side, at the middle of the length of the vessel.

(*a*) On the same principle, in flush-deck vessels, other than spar or awning decked, and in vessels fitted with short poop and forecastle, having an iron upper deck, not covered with wood, the usual thickness of a wood deck should be deducted from the moulded depth of the vessel measured as above, and the amount of reserve buoyancy and corresponding freeboard taken from the column in the tables corresponding with this diminished moulded depth: Example. — In a steamer fitted with an iron upper deck, not covered with wood, and having a moulded depth of 19 ft. 10 ins., four inches, or the usual thickness of a wood deck, must be deducted from this, leaving a depth of 19 ft. 6 ins. The freeboard of such a vessel with a coefficient of fineness of 0.76, taken from the column under 19 ft. 6 ins., is 3 ft. $8\frac{1}{2}$ ins., which should be measured from the top of the iron upper deck.

(*b*) In spar-deck vessels having iron spar decks and in awning-deck vessels having iron main decks, the freeboard required by the tables should be measured as if those decks were wood covered. Also in vessels where $\frac{7}{10}$, or more, of the main deck is covered by substantial erections, the freeboard found from the tables should be measured amidships from a wood deck, whether the deck be of wood or iron. In applying this principle to vessels having shorter lengths of substantial enclosed erections the reduction in freeboard, in consideration of its being measured from the iron deck, is to be regulated in proportion to the length of the deck covered by such erections. Thus in a vessel having erections covering $\frac{6}{10}$ of the length, the reduction is $\frac{6}{10}$ of $3\frac{1}{2}$ inches, or 2 inches.

7. For vessels which trim very much by the stern, through the engines being fitted aft, the freeboard, as ascertained from the tables, if set off amidships would not cut off the amount of surplus buoyancy deemed necessary, and in such cases the suitable freeboard amidships could only be determined after full information is obtained regarding the vessel's trim.

8. The following example will illustrate the general application of the tables:

In a steamer of the following dimensions, viz., length, 204 ft.; breadth extreme, 29 ft.; depth of hold, 16.0 ft.; registered tonnage under deck, 628 tons; and moulded depth, 17.0 ft.; the under deck capacity in cubic feet is 68,200; by dividing this by 94,656, that is, the product of the length, breadth, and depth of hold, the quotient is 0.72, or the coefficient of fineness.

If we now refer to Table A at 17.0 ft. moulded depth and trace the line opposite the coefficient 0.72 to the column corresponding with this depth, it is found that the winter freeboard given for a first-class steam vessel without erections, whose length is twelve times the moulded depth, is 2 ft. 11 ins., corresponding with a reserve buoyancy of 25 per cent of the total bulk.

9. Vessels of Extreme Proportions. — For vessels whose length is greater or less than that of the vessel of the same moulded depth for which the tables are framed, the freeboard should be increased or diminished as specified in the footnote to the tables. Thus, if the vessel in the example clause 8 were 224 ft. long, the winter freeboard required would be 2 ft. 11 ins. plus 2 ins. or 3 ft. 1 in. For steam vessels coming under paragraphs 11 and 12 with enclosed erections extending over $\frac{6}{10}$, or more, of the length of the vessel, the correction for length should be one-half that specified in Tables A.

10. Breadth and Depth. — In framing the tables it has been assumed that the relation between the breadth and depth is such as to ensure safety at sea with the freeboard assigned when the vessel is laden with homogeneous cargo; for vessels of less relative breadth the freeboard should be so increased as to provide a sufficient range of stability, or other means adopted to secure the same.

11. Erections on Deck. — For steam vessels with top-gallant forecastles having long poops, or raised quarter-decks connected with bridge-houses, covering in the engine and boiler openings, the latter being entered from the top, and having an efficiently constructed iron bulkhead at the fore end, a deduction may be made from the freeboard given in the tables, according to the following scale:

(*a*) When the combined length of the poop, or raised quarter-deck, bridge-house, and top-gallant forecastle is:

$\frac{95}{100}$ of the length of the vessel, deduct 90 per cent of the difference between freeboards in Tables A (after correction for sheer) and Tables C.

$\frac{9}{10}$ of the length of the vessel, deduct 85 per cent of the difference between freeboards in Tables A (after correction for sheer) and Tables C.

$\frac{85}{100}$ of the length of the vessel, deduct 80 per cent of the difference between freeboards in Tables A (after correction for sheer) and Tables C.

$\frac{8}{10}$ of the length of the vessel, deduct 70 per cent of the difference between freeboards in Tables A (after correction for sheer) and Tables C.

$\frac{7}{10}$ of the length of the vessel, deduct 55 per cent of the difference between freeboards in Tables A (after correction for sheer) and Tables C.

$\frac{6}{10}$ of the length of the vessel, deduct 40 per cent of the difference between freeboards in Tables A (after correction for sheer) and Tables C.

When the engine and boiler openings are protected only by a long raised quarter-deck, a less reduction in freeboard will be allowed.

(*b*) For intermediate lengths of erections the amount of the reduction in freeboard should be ascertained by interpolation.

(*c*) The above scale of allowance is prepared for vessels having long poops or raised quarter-decks 3 ft. high for vessels having a length of 100 ft., 4 ft. high at a length of 250 ft., and 6 ft. high at a length of 400 ft. and upwards. Intermediate lengths in proportion. For raised quarter-decks of less height the length allowed is to be in proportion to the standard of height.

(*d*) It is to be understood in the application of this scale of allowance for erections on deck to vessels with long poops or with raised quarter-decks and bridge-houses combined, that the deduction is a maximum deduction, applicable only to vessels of these types in which the erections are of a most substantial character, the deck openings most effectually protected, and the crew are either berthed in the bridge-house, or the arrangements to enable them to get backwards and forwards from their quarters are of a satisfactory character. For other vessels of the same class the amount of the deduction should be fixed only after a careful survey. Also such vessels when employed in the Atlantic trade will require to have specially provided greater freeboard than that given in the tables.

(*e*) A sufficient number of clearing ports, as large as practicable and with shutters properly hung, should be formed in the bulwarks of these vessels, between the forecastle and the bridge-house for the purpose of speedily clearing this part of the deck of water.

12. When the erections on a vessel consist of a top-gallan forecastle, a short poop having an efficient bulkhead, an bridge-house disconnected, the latter in steamers covering th engine and boiler openings and being efficiently enclosed wit an iron bulkhead at each end, a deduction may be made fror the freeboard given in the tables according to the followin scale:

(*a*) When the combined length of the erection is:

$\frac{95}{100}$ of the length of the vessel, deduct 75 per cent of the di ference between freeboards in Tables A (after correction fo sheer) and Tables C.

$\frac{90}{100}$ of the length of the vessel, deduct 70 per cent of th difference between freeboards in Tables A (after correction fo sheer) and Tables C.

$\frac{80}{100}$ of the length of the vessel, deduct 60 per cent of th difference between the freeboards in Tables A (after correctio for sheer) and Tables C.

$\frac{70}{100}$ of the length of the vessel, deduct 50 per cent of th difference between the freeboards in Tables A (after correctio for sheer) and Tables C.

$\frac{60}{100}$ of the length of the vessel, deduct 40 per cent of th difference between the freeboards in Tables A (after correctio for sheer) and Tables C.

$\frac{50}{100}$ of the length of the vessel, deduct 32 per cent of th difference between the freeboards in Tables A (after correctio for sheer and length) and Tables C (after correction for length

13. When the erections on a vessel consist of a top-gallan forecastle and bridge-house only, the latter in steamers cove ing the engine and boiler openings and being efficiently enclose with an iron bulkhead at each end, a deduction may be mad from the freeboard given in the tables according to the follow ing scale:

(*a*) When the combined length of the erections is:

$\frac{5}{10}$ of the length of the vessel, deduct 30 per cent of th difference between the freeboards in Tables A (after correctio for sheer and length) and Tables C (after correction for length

$\frac{4}{10}$ of the length of the vessel, deduct 24 per cent of the diffe ence between the freeboards in Tables A (after correction fo sheer and length) and Tables C (after correction for length).

$\frac{3}{10}$ of the length of the vessel, deduct 10 per cent of the diffe ence between the freeboards in Tables A (after correction fo sheer and length) and Tables C (after correction for length).

14. When the erections on a steam vessel consist of a sho poop or raised quarter-deck of a height not less than that lai down in paragraph 11 and top-gallant forecastle only, th

former being enclosed at the fore end with an efficient bulkhead, and when the engine and boiler openings are entirely covered either by the poop or raised quarter-deck or by a strong iron or steel deck-house enclosing the machinery casings, a deduction may be made from the freeboard given in the tables according to the following scale:

When the combined length of the erection is:

$\frac{4}{8}$ of the length of the vessel, deduct 32 per cent of the difference between the freeboards in Table A (after correction for length) and Table C (after correction for length).

$\frac{3}{8}$ of the length of the vessel, deduct 24 per cent of the difference between the freeboards in Table A (after correction for length) and Table C (after correction for length).

$\frac{2}{8}$ of the length of the vessel, deduct 16 per cent of the difference between the freeboards in Table A (after correction for length) and Table C (after correction for length).

$\frac{1}{8}$ of the length of the vessel, deduct 8 per cent of the difference between the freeboards in Table A (after correction for length) and Table C (after correction for length).

For erections which cover less than $\frac{1}{8}$ of the length of the vessel, the allowance should be in proportion to that for $\frac{1}{8}$ covered. When, however, the engine and boiler openings are not entirely covered by the poop or quarter-deck or by a strong iron or steel deck-house, the allowance for erections should be $\frac{6}{10}$ of that provided by the foregoing scale.

15. When a steam vessel is fitted with a top-gallant forecastle only, the reduction of freeboard is to be in accordance with the preceding paragraph for a poop not covering the engine and boiler openings and a forecastle of the same combined length.

When there is a short poop only, or a raised quarter-deck of a height not less than that laid down in paragraph 11, enclosed at the forward end with an efficient bulkhead and covering the engine and boiler openings, the deduction from the freeboard is to be half the allowance that is given for a poop or quarter-deck of the same character and a forecastle having the same combined length. When the poop or raised quarter-deck does not cover the engine and boiler openings $\frac{6}{10}$ of the foregoing allowance is to be given.

16. When the erections on a sailing vessel consist of a short poop and top-gallant forecastle only, the former enclosed at the fore-end with an efficient bulkhead, the deduction from the freeboard given in the tables should be according to the following scale:

When the combined length of the erection is:

$\frac{4}{8}$ of the length of the vessel, deduct 10 per cent of the reserve

buoyancy, or 12 per cent of the freeboard required for the flush-decked vessel after correction for length;

¾ of the length of the vessel, deduct 8 per cent of the reserve buoyancy, or 10 per cent of the freeboard required for the vessel flush-decked after correction for length;

⅝ of the length of the vessel, deduct 6 per cent of the reserve buoyancy, or 8 per cent of the freeboard required for the vessel flush-decked after correction for length;

½ of the length of the vessel, deduct 4 per cent of the reserve buoyancy, or 6 per cent of the freeboard required for the flush-decked vessel after correction for length. In cases where less than ½ of the length of the vessel is covered by erections, the allowance should be in proportion to that given for erections covering ½ of the length.

17. When a sailing vessel is fitted with a top-gallant forecastle only, the reduction in reserve buoyancy should be one-half that prescribed by the previous paragraph for the case where, in addition to the forecastle, the vessel is fitted with a poop of the same length.

When there is a poop only, the allowance is to be half of that which in this paragraph is given for a forecastle only of the same length.

18. Sheer. — The tables are framed for vessels having a mean sheer of deck measured at the side, as shown in the following table:

	Length Over Which Sheer is Measured.						
	100	150	200	250	300	350	400
	Mean Sheer in Inches Over the Length Specified.						
Flush-deck Vessels.—Sheer to be measured abreast stem and sternpost..	20	25	30	35	40	45	50
Vessels having short poops and forecastles.—Sheer to be measured at points distant ⅙ the length of the vessel from each end.. .	14	18	22	26	30	34	38
Vessels having short forecastles only.—Sheer to be measured abreast the sternpost and at a point distant ⅙ the length from the stem......	14½	18½	23	27	31	35½	40

(*a*) In flush-deck vessels and in vessels to which paras. 11 and 12 apply, when the sheer of deck is greater or less than the above and is of a gradual character, divide the difference in inches between it and the mean sheer provided for by 4 and the result in inches is the amount by which the freeboard amidships should be diminished or increased according as the sheer is greater or less.

(*b*) In vessels having short poops and forecastles, and in those having short forecastles only, the freeboard should be corrected in respect of the excess or deficiency in reserve buoyancy due to variations in sheer from the standard amount over the length uncovered by substantial erections, as provided in the above table. One-fourth the difference between the mean sheer specified and that measured as described is approximately the amount by which the freeboard should be modified in respect of sheer.

(*c*) The divisor 4 is to be used when the sheer is of a gradual character, and is not strictly applicable either to those cases in which the sheer is suddenly increased at the bow or stern, or to those in which it does not maintain its normal rate of increase to the ends of the vessel.

(*d*) In all cases the rise in sheer forward and aft is measured with reference to the deck at the middle of the length, and where the lowest point of the sheer is abaft the middle of the length, one-half the difference between the sheer amidships and the lowest point should be added to the freeboard specified in the tables for flush-deck vessels and for vessels having short poops and forecastles only.

(*e*) Where, as in some instances, vessels fitted with long poops or raised quarter-decks connected with bridge-houses have the deck line rising rapidly from amidships to the front of the bridge, and from that point onwards gradually approaching the normal sheer line, the freeboard may be slightly modified in consideration of the increase of height of deck in the "well."

(*f*) In flush-deck vessels and in vessels having short poops and forecastles the excess of sheer for which an allowance is made shall not exceed one-half the total standard mean sheer for the size of the ship.

(*g*) No decrease should be made in the freeboard of spar- and awning-deck vessels, in respect of excess of sheer.

19. Round of Beam. — In calculating the reserve of buoyancy an allowance has been made of one-quarter of an inch for every foot of the length of the midship beam for the round up. When the round of the beam in flush-decked vessels is greater than given by this rule divide the difference in inches by 2 and diminish or increase the freeboard by this amount. For vessels with erections on deck the amount of the allowance

should depend on the extent of the main deck uncovered. This rule for round of beam does not apply to spar- or awning-deck vessels.

20. As a general illustration of the way in which the tables should be used in modifying the freeboard on account of erections on deck, extreme proportions and variations in sheer, the following may be taken as an example.

A vessel is 234 ft. long, 29 ft. broad, and has a moulded depth of 17.0 ft., the coefficient of fineness being .72. Suppose the vessel to have a poop and bridge-house of the united length of 121 ft., and a forecastle 20 ft. in length, and let the sheer forward, measured at the side, be 4 ft. 6 ins., and aft, 2 ft. 1 in.

	Ft.	In.
Freeboard by Tables A if of the normal length, without erections, and with the normal amount of sheer................	2	11
The mean sheer by rule is 33.4 ins. or 6 ins. less than that in the vessel, and the reduction in freeboard is 6 ins. divided by 4	0	$1\frac{1}{2}$
Freeboard of vessel without erections and with $39\frac{1}{2}$ ins. mean sheer......................	2	$9\frac{1}{2}$
Freeboard by Tables C as awning-decked..	0	$9\frac{1}{2}$
Difference	2	0

The combined length of the erections is $\frac{141}{234}$ or $\frac{6}{10}$ of the length of the vessel, and the allowance for erections under clause 11 will be therefore $\frac{4}{10}$ of 24 ins., or $9\frac{1}{2}$ ins.

We have therefore:

	Deduct. in.
Amount deducted from freeboard for excess of sheer.........................	$1\frac{1}{2}$
Amount deducted from the freeboard for erections..........................	$9\frac{1}{2}$
Amount deducted if vessel be fitted with an uncovered iron main deck (clause 6) $= \frac{9}{10} \times 3\frac{1}{2}$.....................	2
	13
The length being 30 ft. in excess of that for which the tables are framed, the addition to the freeboard in respect of the same is one-half of $\frac{30}{10}$ of 1.1 in., or	$1\frac{1}{2}$
	$11\frac{1}{2}$

That is $11\frac{1}{2}$ ins. to be deducted from 2 ft. 11 ins., leaving a winter freeboard of 1 ft. $11\frac{1}{2}$ in.

Corresponding summer freeboard, 1 ft. 9 ins.

21. Vessels loaded in fresh water may have less freeboard than that given in the several tables according to the following scale:

Moulded Depth in Feet.	Reduction in Freeboard.		
	Vessels Without Erections on Deck.	Awning-deck Vessels.	Spar-deck Vessels.
	Ins.	Ins.	Ins.
6 and under 8	1½	....	....
8 " " 11	2	....	....
11 " " 13	2½	....	....
13 " " 16	3	3½	4
16 " " 19	3½	4	4½
19 " " 22	4	4½	5
22 " " 25	4½	5	5½
25 " " 28	5	5½	6
28 " " 31	5½	6	6½
31 " " 34	6	6½	7

Memo.—The weight of a cubic foot of salt water is taken, in the above table, to be 64 lbs., and that of fresh water 62.5 lbs.

22. The freeboards assigned by the following tables are not intended to apply to vessels when navigating inland waters or rivers, and when a stretch of such water has to be traversed such deeper loading will be permissible as may be due to the weight of fuel required for consumption between the points of departure and the open sea.

23. The freeboards of vessels having ports, scuppers, or other openings in their sides is to be regulated by the following considerations. When the openings are in the nature of water-tight ports for cargo, coals, etc., and are therefore not intended to be opened except in harbor, no modification of the freeboard as determined by the foregoing tables will be necessary, provided the covers of the openings are sufficiently strong and are efficiently secured. In the case, however, of vessels having scuppers through the sides from a 'tween deck space below the upper deck or side scuttles or other openings of a similar nature, when the freeboard as determined by the foregoing tables does not provide a sufficient height from the load-line to the sills of the side scuttles, or to the deck which is drained by the scuppers, the freeboard is to be increased; and the amount of the increase,

if any, is to depend on the nature of such openings and on th means adopted for closing them. In the case of hinged sid scuttles of the usual pattern, when the glass is of sufficier thickness and the scuttles are efficiently secured by metal bolt and nuts, and hinged watertight iron shutters of deadlights ar provided on the inside of the glass, the loadline as determine by the centre of the disc or by the Indian summer line, if s marked, is to be not less than 6 inches below the sill of th lowest side-scuttle.

24. The freeboards required by the foregoing tables are t be assigned on the condition that the engine and boiler casing above the upper deck are of sufficient height and strengt with suitable means provided for closing all openings in the in bad weather, and the weather deck hatchways are properl framed with substantial coamings, and strong hatch cover the latter being efficiently supported by shifting beams an fore-and-afters suitable to the dimensions of the hatchwa When these conditions are not complied with the freeboar may require to be increased, regard being given, however, t the trade in which the vessel is intended to be employed.

25. In no case shall the deepest loadline in salt water, wheth indicating the summer or Indian summer line, be assigned at higher position than the intersection of the top of the upp deck with the vessel's side, at the lowest part of the deck.

In the case of shelter-decked vessels the deck next below th shelter deck is to be regarded as the upper deck.

Memorandum of Explanatory Notes on the Applicatio of the Tables of Freeboard, Drawn Up with a Vie to Securing Uniformity of Practice on the Part o Those Entrusted with the Assignment of Freeboar

Deck Line.—In the case of vessels with uncovered iron o steel decks, a width of gutter waterway is to be assumed, an the point so obtained levelled out to the vessel's side. In th case of vessels of 24 feet beam and under, the width of th waterway assumed should be 12 inches, and in vessels of 42 fe and above, 21 inches. In vessels of between 24 and 42 fe beam the width of the gutter waterway is to be taken as ha an inch for every foot in beam.

Where a wood deck maintains a uniform thickness to the sid of a vessel, the same method should be adopted.

In cases where an iron deck is partly covered with wood, th deck-line is to correspond with the top of the deck amidship

whether the deck at that part be of wood or of iron, and the necessary corrections should be made in accordance with paragraph 6, as also the correction always required to the statutory deck-line.

Bridge-house in Spar-decked Ships.—In a spar-decked ship, where an efficient bridge-house is fitted amidships, covering the engine and boiler openings, if it extends over at least two-fifths of the vessel's length and has scantlings not less than the requirements of Lloyd's Rules (1885) for bridge-houses, it is to be taken into consideration in estimating the strength of the vessel for freeboard.

If the scantlings of the bridge-house are equal to the requirements of Lloyd's Rules (1885) the allowance on this account should not exceed that given in the following table:

MOULDED DEPTH OF VESSEL TO MAIN-DECK.	ALLOWANCE.
Feet.	Inches.
16.	4
20.	3
24.	2
28.	1

If, however, the scantlings of the bridge-house are in excess of Lloyd's Rules (1885) the freeboard is to be determined on the basis of a comparison between the strength of the actual vessel and the strength of a vessel of the same dimensions, built to the three-decked rule, and of a vessel built to the spar-deck rule, including a bridge-house in each case.

Tables of Freeboard.—Additional freeboard will be required in the case of vessels classed 90A and 80A, or in vessels of equivalent strength thereto in accordance with the following scale:

Length of vessel:

FEET.	150	175	200	225	250	275	300
	In.	In.	Ins.	Ins.	Ins.	Ins.	Ins.
90A additions	½	½	½	¾	¾	1	1¼
80A "	1	1	1¼	1½	1¾	2	2½

Wherever in these explanatory notes reference is made to classes of vessels of Lloyd's various types, it is to be under-

stood that these apply equally to all other vessels of equival strength, whether classed by other classifying associatio such, for instance, as the Bureau Veritas or the British C poration, or unclassed.

If the frame spacing be increased one-fourth, the thickness all the shell-plating, excepting garboard and sheer strak should be increased by one-twentieth of an inch over the thic ness required in the standard ship. Other increases in spaci should be dealt with in the same proportion.

PARA. 1 — LENGTH. — The length of erection is to be measur with reference to the length of the vessel on the load-line, i. any portion of the erections forward of the fore side of the st on the load-line, or abaft the after side of the after post on t load-line, is not to be measured for deductions.

PARA. 3 — DEPTH OF HOLD. — The depth of hold as used the computation for ascertaining the coefficient of fineness iron and steel sailing vessels is to be measured to the top of t ceiling, and in steam vessels to the top of the floors.

The cases of vessels having either an excess or a deficiency mean sheer, as compared with the standard sheer, the register depth to be used for ascertaining the coefficient of fineness is be increased for excess of sheer, or reduced for the deficiency sheer, by one-third of the difference between the standa mean sheer and the vessel's actual mean sheer, after being r duced to the gradual character, if necessary.

PARA. 4 — COEFFICIENT OF FINENESS. — No alteration is be made in the freeboard in consequence of the coefficient fineness being either smaller or greater than those given on t page of the tables from which the ship's freeboard is taken.

PARA. 5 — MOULDED DEPTH. — In cases where a wood de of extra thickness is fitted, or where a wood deck is doubl throughout, the moulded depth should be increased by the e cess of thickness. The freeboard should then be set off from t top of the deck of increased thickness at the side of the vessel.

PARA. 6 — FREEBOARD. — In case of the freeboard bei ascertained by an actual calculation of the reserve buoyanc the drawing used in such calculation should be verified b actual measurements at the ship, and such drawing and calc lations forwarded to the Board of Trade, and, whatever t result of the calculation, the freeboard assigned should not l less than would be obtained by taking from the tables the fre board corresponding to the smallest coefficient for a vessel the same moulded depth, except in sailing vessels with lar rise of floor (see page 26).

Freeboard as ascertained by these tables is to be measured to the intersection of the deck with the side of the vessel, but in granting certificates of freeboard this must always be corrected so as to state the freeboard amidships when measured to the deck-line, marked in accordance with the statute.

SUB-PARAS. (A) AND (B). — For vessels having iron upper-decks not covered with wood, the allowance is to be made under sub-para. (*a*), when the erections extend over less than $\frac{4}{10}$ of the length; but in all vessels when the erections cover $\frac{4}{10}$ or more of the length, and in spar- and awning-decked vessels the allowance is to be made under sub-para (*b*).

SUB-PARA. (*b*.) — (*b*.) — In spar-decked vessels having iron spar decks and in awning-decked vessels having iron main decks, the freeboard by the tables should be calculated, as if those decks were wood-covered, i.e., the ordinary thickness of a wood deck, less the thickness of the stringer plate, should be deducted from the freeboard, also in vessels where $\frac{7}{10}$ or more of the main deck is covered by substantial enclosed erections, the freeboard found from the tables should be measured amidships from a wood deck, or, if the deck is of iron, it should be measured from the iron deck, and the ordinary thickness of a wooded deck required for that size of ship, less the thickness of the stringer plate, should in that case be deducted from the freeboard. In vessels which have $\frac{6}{10}$ of the deck covered, $\frac{6}{10}$ the thickness of a wood deck, less the thickness of the stringer plate is to be deducted from the freeboard. Between $\frac{6}{10}$ and $\frac{7}{10}$ a proportionate quantity; for example, for $\frac{65}{100}$ covered allow $\frac{8}{10}$ the thickness of the deck, after deducting the thickness of the stringer plate. The remainder of the paragraph should be read as printed. N.B. — When the deductions referred to in this sub-para. (*b*) are allowed the moulded depth is not to be reduced as per sub-para. (*a*) para. 6.

PARA. 9. — In the case of vessels coming under para. 12 and having the deck erections not entirely enclosed, the effective length of the open portions is to be assessed as described in paras. 13, 14 and 15; if the length of the enclosed erections plus the length of the open portions, where assessed as above, is at all under $\frac{6}{10}$ of the vessel's length, the entire correction for length is to be applied.

PARA. 11. — This paragraph does not apply to vessels in which the effective length of the erections is less than $\frac{6}{10}$ of the length, except in cases where the effective length of the after erection is at least $\frac{4}{10}$ of the length, and the total effective length of the erections is between $\frac{5}{10}$ and $\frac{6}{10}$ of the length of the vessel.

In such cases the allowance should be proportioned betw that allowed for erections $\frac{1}{10}$ the length under para. 14 and th allowed for erections covering $\frac{4}{10}$ of the length under para. and the corrections for length and sheer should be included estimating this allowance. In all other cases of vessels w erections covering less than $\frac{4}{10}$ of the length, para. 14 is to used.

In the case of vessels having erections which are partly op or are less than the standard height the effective length of t erections is to be computed as directed elsewhere.

No allowance is to be made for a monkey forecastle which less in height than the main or top-gallant rail, or 4 feet, whic ever is the least; where this condition is satisfied, or the fo castle is a sunk one having an efficient bulkhead at its af end, the length to be used in estimating the allowance is to obtained by multiplying the length of the monkey forecas by its height and dividing by 6 feet, the minimum height of top-gallant forecastle. This rule, as well as that relating to t heights of raised quarter-decks, applies to vessels coming und paras. 12, 13, 14, and 15, as well as under para. 11. In case vessels having no forecastle but in other respects coming u der this paragraph, the allowance for erections should be es mated on the supposition that there is a forecastle of $\frac{1}{4}$ t length of the vessel, deducting from this twice the allowan which the vessel would have for such a forecastle under para. I

Sub-para. (*a*). — The difference will not be affected by co rection for length, as the allowance will be practically the sa in both tables.

Sub-para. (*c*). — The engine and boiler openings, if pr tected only by a raised quarter-deck, will require an addition freeboard varying from 1 inch in vessels of 15 feet mould depth to 2 inches in vessels of 20 feet moulded depth. In ve sels having less than 15 feet moulded depth a proportiona addition should be made.

If with a small bridge-house in front of, but not covering t openings, an addition of half the above amount.

Sub-para. (*d*). — If the crew are not berthed in the bridg house, and the arrangements to enable them to get backwar and forwards from their quarters are not satisfactory, an a dition should be made to the freeboard of 1 per cent of th moulded depth of the ship in the case of vessels 180 feet more in length and having wells 70 feet or less in length. the vessel's length does not exceed 150 feet, or if the well is feet or more in length, the foregoing addition will not be r quired. In the case of vessels between 150 and 180 feet

length, or having wells between 70 and 80 feet in length, the addition is to be found by interpolation.

Planks secured in position by lashings are not to be regarded as satisfactory arrangements; and a gangway providing access between the bridge-house and forecastle cannot be considered satisfactory, unless the following requirements at least are complied with:

The gangway to be not less than 18 inches wide and to be efficiently supported at suitable intervals. The ends to be strongly bolted to lugs riveted to the bulkheads of bridge and forecastle, or to the hatch coamings, or to iron standards bolted to the deck or to be secured in some equally efficient manner.

The top of the gangway to be not less than 2 feet 6 inches above the top of the deck at any part. A life-line or rail to be fitted for the entire length of the gangway and to be supported by wrought-iron stanchions suitably spaced and not less than 2 feet 6 inches in height.

If the hatchways are at least 2 feet 6 inches in height the gangway may be fitted between the hatchways and beyond them only, provided that a continuous platform of at least the required height is obtained, and the rail or life-line is fitted and efficiently supported by wrought-iron stanchions for the entire distance including the hatchways. The gangway should be fitted as far inboard as practicable.

SUB-PARA. (*e*). — The minimum freeing port area is to be as follows:

LENGTH OF BULWARKS IN "WELL," IN FEET.	FREEING PORT AREA ON EACH SIDE IN SQUARE FEET.
5	4.5
10	6.5
15	7.5
20	8.5
25	9.
30	9.5
35	10.
40	10.5
45	11.
50	11.5
55	12.
60	12.5

65 and above, 1 square foot to each 5 feet length of bulwark.

If the freeing port area is less than that stated above, an addition is to be made to the freeboard of 1 per cent of the moulded depth.

The scale of allowance for erections on deck to vessels with top-gallant forecastles having long poops or raised quarter-decks connected with bridge-houses is not to be used without modification, unless the strength of the bulkhead at the front of the poop or bridge-house is at least equivalent to the following requirements:

(*a*) Poop or bridge bulkheads to be of the thickness of their side plating as required below for vessels under 13 depths to length, with coaming plates $\frac{1}{20}$ of an inch thicker, and to be stiffened with bulb angle according to the following scale, spaced 30 inches apart, and connected to the coaming plates and to the deck plating, or to an athwartship plate on the beams both below and above, with a bracket plate to each end of the stiffener.

Breadth of Ship	Size of Stiffener.	Breadth of Ship.	Size of Stiffener.
24	$5\times3\times\frac{8}{20}$	46	$7\frac{1}{2}\times3\frac{1}{2}\times\frac{11}{20}$
30	$6\times3\times\frac{9}{20}$	50	$8\times3\frac{1}{2}\times\frac{12}{20}$
36	$7\times3\times\frac{10}{20}$	54	$8\frac{1}{2}\times3\frac{1}{2}\times\frac{13}{20}$
42	$7\times3\times\frac{11}{20}$	58 and above	$9\times3\frac{1}{2}\times\frac{13}{20}$

Intermediate sizes to be found by interpolation.

(*b*) Horizontal brackets or gusset plates of the same thickness as the coamings to be fitted, connecting the poop or bridge bulkheads with the bulwarks on each side of the vessel at about the height of the rail. In the case of vessels having a forecastle and raised quarter deck only, the break bulkhead should be the same thickness as required for bridge sides and stiffened with angles 30 inches apart and of the size required for the main frames.

In order to obtain the allowance for deck erections provided by this paragraph, the openings, if any, in the bulkhead at the front of the long poop or bridge house, must be provided with hinged iron or steel doors, or with some equally permanent means of closing such openings. When the width of the openings exceeds 30 inches, special means are to be provided for maintaining the strength of the hinged doors.

The standard of thickness of the side plating of long poops and bridge-houses is that required by Section 44 of Lloyd's Rules, as modified by the Table of Thicknesses of Side Plating of Awning-decked Vessels, given in these tables.

The additional freeboard for North Atlantic winter is to be as follows:

ADDITIONAL FREEBOARD FOR WINTER, NORTH ATLANTIC, FOR WELL-DECK VESSELS.

Length of Vessels	Proportions of Length of Vessel Over Which Erections Extend				
	$\frac{60}{100}$	$\frac{65}{100}$	$\frac{70}{100}$	$\frac{75}{100}$	$\frac{80}{100}$
Ft.	Ins.	Ins.	Ins.	Ins.	Ins.
180	4	$3\frac{1}{2}$	3	$2\frac{1}{2}$	2
220	$3\frac{1}{2}$	$3\frac{1}{2}$	3	$2\frac{1}{2}$	2
260	$3\frac{1}{2}$	3	$2\frac{1}{2}$	2	2
300	3	3	$2\frac{1}{2}$	2	....

Para 12. — For vessels having no forecastle, but with the other deck erections prescribed in this paragraph, estimate the allowance for erections supposing there is a forecastle $\frac{1}{8}$ the length of the vessel, and deduct $1\frac{1}{2}$ times the allowance that would be made under para. 15 if the vessel were fitted with such a forecastle only.

This rule also applies to vessels having no forecastle, but with a bridge-house, as provided for in para. 13.

In steam vessels coming under this paragraph, and having closed erections extending over $\frac{6}{10}$ or more of the vessel's length, one-half the length correction specified in Table A is to be made, and the freeboard corrected for sheer only in estimating the allowance for erections, as the allowance for length will be practically the same in both Tables.

For erections which extend over less than $\frac{4}{10}$ the length of the ship, the allowance is to be in proportion.

For instance, if $\frac{3}{10}$ are covered, allow $\frac{3}{4}$ of 25 per cent.

In the case of vessels under 15 ft. moulded depth, in which the combined length of enclosed erections exceeds $\frac{5}{10}$ of the vessel's length, or in which the combined length of erections enclosed and open is equivalent to more than $\frac{5}{10}$ the vessel's length, sub-paras. (*d*) and (*e*) of the preceding paragraph are to apply; but the full addition of one per cent of the moulded depth, under each of these sub-paragraphs, is to be made only when the erections cover $\frac{6}{10}$ or more of the length; for lengths of erections intermediate between $\frac{5}{10}$ and $\frac{6}{10}$, the required addition is to be in proportion; thus, when $\frac{55}{100}$ of the vessel's length is covered, the addition to the freeboard is to be $\frac{1}{2}$ per cent of the moulded depth under each sub-paragraph.

Paras. 12 and 13. — The allowance in a sailing ship for a bridge-house in addition to a poop or forecastle, or in addition to a forecastle only, is obtained by the rules laid down in paras. 12 and 13, as the case may be, and is calculated upon the difference between the freeboards of Tables A and C; in other words, the allowance for a forecastle, bridge-house, and poop, or for a forecastle and bridge-house in a sailing ship, is the same as would be given for similar erections in a steamer of the same dimensions.

Para. 13. — When the combined length of the top-gallant forecastle and bridge-house is $\frac{5}{10}$ of the length of the ship, a deduction from the freeboard may be made of $\frac{8}{100}$, and this is the maximum deduction for this type of vessel.

For erections which extend over less than $\frac{8}{10}$ of the length of the ship the allowance is to be in proportion.

For instance, $\frac{9}{10}$ covered allow $\frac{2}{3}$ of 19 per cent.

In all the rules governing the deductions to be made from the freeboard it is to be understood as follows: When the top-gallant forecastle is not closed by an efficient bulkhead at the after end the length is never to be estimated at a greater full value than $\frac{1}{8}$ the length of the ship, but any extension beyond this may be estimated at one-half the value. For instance, if a vessel 240 feet long has an open forecastle 80 feet long, its value for deductions is $30 + 25 = 55$ feet. When the top-gallant forecastle has an efficient bulkhead with an elongation abaft that bulkhead not enclosed at the after end, the full value of the closed-in portion is to be estimated either as $\frac{1}{8}$ the length of the ship, or the entire length of the enclosed portion, whichever may be the greatest.

Open-bridge House. — When the bridge-house extends from side to side of the ship its value for deductions must be considered on its merits, which will depend upon the security of all deck openings, doors, bunker lids or otherwise.

Where these are all properly protected and the bridge-house is open at both ends, one-half the length may be estimated as the value for deductions. Where in addition the fore end is enclosed by an efficient bulkhead $\frac{3}{4}$ the length may be estimated as the value for deductions.

If the openings in the bulkhead at the after end of a bridge erection, having its fore end closed, are efficiently protected by weather boards properly fitted to at least half the height of the erection, the full length of the erection may be allowed in estimating its value for freeboard. This does not apply, however, to the case of a long erection falling to be dealt with under paragraph 11, as in well-decked vessels having the well aft,

except in shelter-decked vessels having efficient means provided for temporarily closing the openings in the shelter-deck in bad weather.

In the case of steamers coming under paragraphs 12 and 13, when the engine and boiler openings are not covered by an erection extending from side to side, bridge-houses may have an allowance not exceeding that which would be given for half the length of a bridge-house of the same character covering engines and boilers.

Paras. 14 and 15. — When the poop has no efficient bulkhead, or the bulkhead does not extend across the vessel, one-half its length may be allowed, provided always proper freeing ports are fitted.

When the openings in the bulkhead are provided with efficient weather boards or other efficient temporary means of closing, and extending the full height of the openings, then the full length of the poop may be allowed.

In no case, however, shall shifting boards or any other temporary means of closing the openings in the bulkheads at the after end of a bridge-house, or fore end of a poop be considered satisfactory, unless the means of their attachment, whether by channels, hooks, cleats, or otherwise, are permanently secured to the bulkheads.

The standard heights of forecastles and raised quarter-decks, as defined in para. 11, pages 6 and 16, apply also to these paragraphs.

Paras. 16 and 17. — In the case of a sailing vessel having a forecastle and raised quarter-deck, or a raised quarter-deck only, the latter of less than 4 feet in height, the length of raised quarter-deck to be allowed should be in proportion to its height as compared with the standard height of 4 feet.

The provisions of the preceding paragraphs relating to the height of forecastles, bulkheads at the after end of forecastles and at the fore end of poops, and the means of closing openings in poop bulkheads, are also to be applied to sailing vessels dealt with under paras. 16 and 17.

"Para. 18. Sheer. — Sheer of a gradual character is to be defined as follows: —

"At $\frac{1}{8}$ the length of the vessel from the stem or sternpost the sheer is to be 55 per cent of the sheer at stem or sternpost; at $\frac{1}{4}$ the length from stem to sternpost 26 per cent, and at $\frac{3}{8}$ the length 7 per cent.

"In those cases in which the sheer is required to be taken at the stem and sternpost and the sheer is found to be not of the grad-

ual character, the following method of computing the effective mean sheer is to be used: —

"Let S = mean of the actual sheers at stem and sternpost;

"Let S_1 = mean of sheers at $\frac{1}{8}$ length from stem and sternpost $\div .55$.

"If S is greater than S_1 the effective mean sheer to be used in the computation of freeboard is S_1.

"If S is less than S_1 the effective mean sheer to be used is $\frac{S+S_1}{2}$

"In those cases in which the sheer is required to be taken at $\frac{1}{8}$ of the vessel's length from stem or from sternpost the sheer as actually measured at the prescribed point may be used in ordinary cases without any correction on account of a departure of the sheer line from the gradual character.

"When correcting the depth of hold for excess or deficiency of sheer (paragraph 3, page 23), the mean of the sheers at $\frac{1}{8}$ of vessel's length from stem and from sternpost divided by .55 should in all cases be taken as the vessel's actual sheer for this purpose.

In cases where there is no forecastle the sheer is to be measured at the stem and sternpost, and corrections made for it in all respects as in the case of flush-decked vessels.

When the bridge-house is enclosed, the sheer should be taken at the stem and sternpost and the freeboard corrected for sheer in estimating the allowance for erections. When the bridge-house is not enclosed at both ends, the sheer should be measured as if there were no bridge-house, and the freeboard should or should not be corrected for sheer in estimating the allowance for erections, according as the sheer is measured at the stem or at $\frac{1}{8}$ length from the stem.

SUB-PARA. (*a*). — Surveyors should note that paras. 11 and 12 apply either to vessels of the ordinary well-decked type or to vessels having a poop and forecastle with a disconnected bridge-house.

SUB-PARA. (*d*). — The extent of the depressed part of the sheer covered by deck erections is to be allowed for in applying this rule.

SUB-PARA. (*e*). — In vessels obtaining an allowance for deck erections under para. 11 and having considerably less than the normal sheer, the freeboard should be modified in consideration of the decrease of height of deck in the "well."

SUB-PARA. (*f*). — In flush-deck vessels the total standard means the sheer measured at the stem and sternpost. In vessels

having poops and forecastles, it means the sheer measured at points distant $\frac{1}{8}$ of the vessel's length from stem and stern-post.

In vessels obtaining an allowance for deck erections under para. 11, where the sheer drops abaft amidships, the height of the raised quarter-deck is to be taken from the level of the top of the midship beam.

Para. 19 — Round of Beam. — In flush-deck sailing vessels the excess of round of beam for which an allowance is made shall not exceed the standard round of beam; and for sailing vessels having erections on deck the allowance shall be further reduced in proportion to the extent of the main deck uncovered.

Table A.

The deductions for summer in vessels having deck erections is to be intermediate between those required by Tables A and C in proportion to the length of the ship covered by those erections.

Table B.

All vessels equal in strength to Lloyd's spar-decked rule, or which, although in excess of that rule, do not come up to Lloyd's requirements for ships of full scantlings to the upper deck, are to be considered as spar-decked ships, the freeboard for which will vary with their strength.

When the height between decks is greater or less than 7 feet, the consequent modification in freeboard will vary from $\frac{1}{3}$ to $\frac{2}{3}$ the excess or deficiency of height, the exact proportion to depend upon the strength of the vessel.

In spar-decked vessels where the height between main and spar deck exceeds 7 feet, the numbers for scantlings should be found assuming the height between decks to be 7 feet; if both these numbers are in the same grades as the actual scantling numbers of the vessel, the correction for height between decks is to be $\frac{1}{3}$ of the excess of height above 7 feet. If both the scantling numbers so found are in higher grades than those of the actual vessel, $\frac{2}{3}$ of the excess of height is to be added, and if either one of these scantling numbers is in a higher grade, $\frac{1}{2}$ of the excess of height is to be added. The same principle will apply in cases where the height between decks is less than 7 feet.

Since the freeboard is measured from the spar deck, it will be increased if the 'tween deck height is more, and decreased if it is less than 7 feet.

In computing the freeboard of spar-decked vessels having scantlings in excess of Lloyd's requirements, a comparison is to be made between their scantlings, the scantlings of vessels of the same dimensions classed 100 A built to the three-decked rule, and of vessels built to the 100 A spar-decked rule, and the freeboard is to be proportionate between that given in Table A and that given in Table B, after deducting 12 per cent from the former; but in no case must the freeboard so assigned be less than that provided in Table A, for a vessel of the same dimensions, sheer, and camber, or round of beam, and deck erections.

In the comparison of scantlings and assignment of freeboard to spar-decked vessels having scantlings in excess of Lloyd's requirements, the following method is to be adopted:

1. The difference between the freeboard by Table A (less 12 per cent) and that by Table B to be divided by five, $\frac{3}{5}$ of it being considered with reference to the longitudinal strength, and $\frac{2}{5}$ of it with reference to the transverse strength, these allowances to be the maximum deduction on each account.

2. In the comparison of steel ships, notwithstanding the general reduction of 20 per cent for steel as compared with iron thicknesses, outside plating in the way of the double bottoms is not to be further reduced by $\frac{1}{20}$ unless its thickness is $\frac{11}{20}$ or over. No reduction is to be made in any case unless there are floors connected with every frame.

3. In the calculation of strength the following method is to be adopted:

(*a*) Thin iron or steel plating in weather decks and the inner plating of double bottoms are to have their sectional area reduced for the purpose of the strength calculation as follows:

1. When the deck beams or floors are fitted on every frame of the usual spacing:

Thickness in 20ths	5	6	7	8	9
	.6	.7	.9	1	1

2. When the deck beams or floors are fitted on alternate frames:

Thickness in 20ths	5	6	7	8	9
	.4	.5	.6	.7	.8

When the decks are sheathed with wood, with fastenings not more than 24 inches apart, the factors given in (1) are to be used, whether the beams are on every frame or on alternate frames, but if the fastenings are 48 inches apart, then the fac-

tors in (2) are to be used unless the beams are fitted on every frame.

(*b*) A deduction of $\frac{1}{7}$ is to be made for rivet holes in steel, and $\frac{1}{8}$ in iron for the parts in tension.

(*c*) Iron or steel decks which cover not less than $\frac{3}{5}$ of the midship length of the vessel are to be considered in the calculation just as they would be if of the full length.

(*d*) Such portions of wood weather decks as are continuous throughout the midship portion of the ship are to be considered as equivalent to steel of $\frac{1}{25}$ the section area of the wood.

(*e*) For the purpose of comparison of strength the breadth of the hatchways in the standard vessel shall be deemed to be $\frac{1}{3}$ the breadth of the deck, and the tie-plates should be assumed to be fitted at the side of the hatchways.

Table C.

The standard of strength for awning-decked vessels is that provided by Lloyd's Rules (1885) for 100 A awning-deck class, as modified and extended by the following table showing the thicknesses of topside plating, etc.

All vessels equal in strength to the above standard, or which, although in excess of that standard, do not come up to Lloyd's requirements for a spar-decked vessel, are to be considered as awning-decked vessels, the freeboard of which will vary with their strength.

No modification is necessary in respect of the height of 'tween decks of awning-decked vessels.

In comparing the freeboard for awning-decked vessels having scantlings in excess of the standard requirements, a comparison is to be made between their scantlings, the scantlings of vessels of the same dimensions built to the 100 A spar-decked rule, and of vessels built to the standard awning-decked rule, and the freeboard is to be proportionate between that given in Table B and that given in Table C.

In vessels where the superstructure is of less strength than that required for the standard awning-decked vessel, additions are to be made to the freeboard in the same proportion.

In the comparison of scantlings and assignment of freeboard to awning-deck vessels having scantlings in excess of the standard awning-decked vessel, the method of procedure to be similar to that stated above for spar-deck vessels having scantlings in excess of those provided by the spar-decked rule.

The thickness of the side plating above the main deck of standard awning-decked vessels, for half the vessel's length amidships, is to be in accordance with the following table.

Ratio $\frac{L}{D}$.	Under 13.	13–14	14–15
Plating Number			
10,000 and under 13,100	5	5 and 6	6
13,100 " " 15,500	6	6	6
15,500 " " 16,600	6	6 and 7	7
16,600 " " 18,700	7	7 and 8	8
18,700 " " 26,400	8	8 and 9*	9*
26,400 " " 30,900	8	9*	9 and 10*
30,900 " " 35,200	9*	10*	10†
35,200 " " 40,000	9*	10†	10†

* The butts of the awning-deck sheer strake to be treble riveted, and the landing edges of the side plating to be double riveted.

† The butts of the strake of side plate below the awning-deck sheer strake to be treble riveted in addition.

Note.—For iron read sixteenths and for steel read twentieths of an inch. When two thicknesses are given the greater is that of the awning-deck sheer strake. The depth and length are to be measured as defined in Lloyd's Register Rules for estimating the scantling numbers.

When Section 46 of the above rules (relating to vessel's proportions) applies to these vessels, the increased thicknesses required for sheer strakes, stringers, etc., are to be added to those of the main deck.

When one steel deck is required, it is to be fitted at the main deck, and when two steel decks are required they are to be fitted at the awning-deck and the main-deck, for the purpose of comparison of strength for determination of freeboard.

For vessels having a plating number exceeding 40,000 the scantlings necessary for the standard awning-decked vessel for the Table C freeboard are to be determined so that the stress per square inch upon the material of the hull amidships shall not exceed that of a standard vessel of the same dimensions and form, and having scantlings equal to the requirements of the 100 A class in Lloyd's Register for three-deck vessels when loaded to the freeboard given in Tables A after deducting 12 per cent from the same.

In part awning-decked vessels with raised quarter-decks and long superstructures with the extra strength given in Section 44, Lloyd's Rules for 1889 for iron and steel vessels, where the break of the quarter-deck is $\frac{1}{10}$ the vessel's length abaft amidships, and the continuity of strength is suitably maintained at such break, a reduction may be made from the freeboard required by Table C in accordance with the following scale.

When the break of the quarter-deck is not less than $\frac{8}{10}$ the length of the vessel abaft amidships, twice the above mentioned allowance may be made, and for intermediate lengths of erection the allowance is to be obtained by interpolation.

Vessels with plating number under 18,000, 2½ inches.
Vessels with plating number 18,000 to 21,000, 3 inches.
Vessels with plating number 21,000 to 24,000, 3¼ inches.
Vessels with plating number 24,000 to 27,000, 3½ inches.

In part awning-deck vessels the standard height of the raised quarter-deck is 4 feet; for raised quarter-decks of less height, extending over $\frac{4}{10}$ of the length, the allowance for the erections should be diminished as shown in the following table:

Height of R. Quar. Dk.		Moulded Depth of Vessel in Feet.						
		Ft. In. 10 0	Ft. In. 12 0	Ft. In. 14 0	Ft. In. 16 0	Ft. In. 18 0	Ft. In. 20 0	Ft. In. 22 0
Ft.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
3	6	....	¼	½	½	½	¾	¾
3	0	½	¾	1	1	1¼	1½	1¾
2	6	1	1¼	1½	1¾	2	2½	3
2	0	1½	1¾	2¼	2¾	3¼	3¾	4½
1	6	2	2½	3	3¾	4¼	5	6

For shorter or longer lengths of raised quarter-decks a proportionate correction should be made.

Table D.

Sailing vessels classed *A* (black) in Lloyd's Register are to be regarded as first-class ships in applying the tables.

Hard wood ships, i.e., other than fir or pine, classed *A* (red) in Lloyd's are to have their freeboards by the tables increased by 8 per cent.

Hard wood ships classed Œ in Lloyd's are to have their freeboards by the tables increased 15 per cent.

Hard wood ships without class are to have their freeboard by the tables increased by 20 per cent, unless opened out for survey, when their freeboards will depend upon their condition.

Soft wood ships will require to have their coefficient of fineness modified in respect of the excess of the registered breadth caused by the extra thickness of side. That for hard wood ships is already provided for in the tables.

Soft wood ships classed *A* (red) in Lloyd's are to have their freeboards by the tables increased 10 per cent.

Soft wood ships classed Œ in Lloyd's are to have their freeboards increased 20 per cent.

Soft wood ships without class are to have their freeboards by the tables increased 25 per cent unless opened out for survey when their freeboards will depend upon their condition.

Iron and steel sailing vessels having a greater rate of rise of floor than $1\frac{1}{2}$ inches per foot of half breadth may have the moulded depth to be used with the tables reduced by half the difference between the total rise of floor at the half breadth and the total rise at the standard rate of $1\frac{1}{2}$ inches per foot; $2\frac{1}{2}$ inches per foot of half breadth is to be the maximum rate of rise on which an allowance is to be made. When the reserve buoyancy is calculated, the percentage taken shall be that corresponding to the depth reduced as above, but in no case shall the freeboard be less than that given in the top line of Table D for such percentage. Whichever method be adopted the correction for length is to be applied in relation to the reduced moulded depth.

RULES TO REGULATE THE DEPTH OF LOADING OF TURRET-DECK VESSELS AND VESSELS OF SIMILAR TYPES.

1. A turret is a strongly-constructed continuous erection at the middle line of the vessel, forming with the main or harbour deck an integral part of the hull, having a breadth not less than $\frac{5}{10}$ of the greatest breadth of the vessel and a height not less than 25 per cent of the moulded depth. In assigning freeboards to turret-deck vessels, the following rules should be observed:

2. Hatch coamings at least 2 ft. high and casings to engine and boiler openings at least 4 ft. 6 ins. high to be fitted above the "turret" deck.

Any scuttles or other openings in the harbour deck are to be closed water-tight by means of iron or steel plates not less in thickness than the harbour deck, suitably stiffened and strongly bolted in place. The following method of computing the freeboard is based on the consideration that the turret-deck hatchways are provided with permanent means of closing them, as described in clause 8 of the rules for shelter-decked steamers.

3. The volume of the turret to be estimated from a normal beam line drawn through the point where a vertical line at the quarter breadth of vessel cuts the upper surface of the vessel's deck. Where the turret is nearly one-half the breadth of the

vessel, and its transverse section is of rounded form at its base, the base line of the turret is to be drawn through the point where the vertical line at the quarter breadth cuts the upper surface continued in the same curve as the normal line of beam.

4. The reserve buoyancy required by the tables to be estimated by taking 70 per cent of the volume of the turret. The height of the turret allowed for is not to exceed 25 per cent of the moulded depth. (It is to be understood that no correction is to be made for an unsheathed iron harbour deck in applying the buoyancy method.)

5. The moulded depth of the vessel to be taken to be the depth at side from the beam line, as before defined, to the top of the keel.

6. If a vessel has sheer, to determine the volume of the turret, the turret base line to be drawn at each section as described above. At the extreme fore end of the vessel the base of the turret to be parallel to the turret deck.

7. Where a poop and forecastle or a forecastle only are fitted on the top of a turret, the allowance for them is to be as follows:

When the effective length of these erections is equal to $\frac{1}{4}$ of the vessel's length, deduct 8 per cent of the difference between the freeboards in Table A (after correction for sheer) and Table C.

For erections of greater or less length the allowance is to be in proportion to the length. The allowance for such erections is not to exceed 10 per cent of the difference between the freeboards in Table A (after correction for sheer) and Table C.

The effective length of a poop or forecastle is to be obtained by multiplying its actual length by the ratio which its breadth bears to the breadth of the ship at the after end of the forecastle or fore end of the poop respectively.

The provisions of the freeboard tables regarding the height of forecastles, the bulkheads at the after end of forecastles and at the fore end of poops, and the means of closing the openings in poop bulkheads, are to be applied in these cases.

8. The method described above is only applicable when it is possible to obtain a correct drawing of the "lines" of the vessel, and it is only to be employed when facilities are given for verifying the drawing by actual measurements at the ship, in accordance with para. 6 of the freeboard tables. When a verified drawing is obtainable, either the foregoing or the following method may be employed at the option of the owner, but if a verified drawing is not obtainable, the following method only is to be employed.

9. The depth of hold to be used in obtaining the coefficient of fineness in vessels having either an excess or deficiency of sheer is to be modified as described in para. 3, and the coeffi-

cient thus obtained is to be modified when the vessel is of rounded form at the gunwale, the necessary addition in ordinary cases being .01.

10. The length correction under para. 9 of the load-line tables is to be $\frac{3}{4}$ of that specified in Table A, where the breadth of the turret is $\frac{5}{10}$ of the breadth of the vessel, but the table correction is to be halved where the breadth of the turret is $\frac{6}{10}$ or more of the breadth of the vessel. For turrets having breadths between $\frac{5}{10}$ and $\frac{6}{10}$, the length correction is to be in proportion.

11. In making the sheer correction in accordance with para. 18 of the load-line tables, the sheer is to be measured at the ends of the vessel.

12. The effective length of the turret is to be obtained by multiplying its length by the ratio of the mean breadth of the turret to the breadth of the vessel amidships.

13. The deduction from the freeboard shown in the tables on account of the turret is to be as follows:

Where the effective length of the turret is $\frac{5}{10}$ of the length of vessel deduct 45 per cent of the difference between the freeboards in Table A (after correction for sheer) and Table C. Where the effective length is $\frac{6}{10}$, deduct 55 per cent, and so on in proportion. For intermediate lengths intermediate percentages are to be taken.

14. In those vessels having unsheathed harbour or main decks, a correction should be made, when employing the linear method of computation, as described in para. 6 (*b*).

15. The transverse and longitudinal strength of the vessel are to be regulated by that required for a "three-deck" vessel of the same length, breadth, moulded depth, and coefficient of fineness, and the scantlings of the turret are to be determined so that the stress per square inch upon the material of the turret amidships shall not exceed that of a standard vessel of the same dimensions and form, and having scantlings equal to the requirements of the 100 A class in Lloyd's Register (1885) for three-deck vessels when loaded to the freeboard given in Table A after deducting 12 per cent from the same.

16. Should a vessel be constructed with a turret less than $\frac{5}{10}$ the breadth of the vessel or less in height than $\frac{1}{4}$ of the moulded depth, or should the radius of curvature at the gunwale exceed 20 per cent of the moulded depth, or should the centre line of the disc when ascertained reach a point above the junction of the vertical side with a rounded gunwale, full particulars and calculations with the proposed assignment are to be submitted to the Board of Trade before freeboards are assigned.

17. The freeboards in the certificates issued are to be set off in feet and inches from the line of the turret deck.

RULES FOR THE DETERMINATION OF THE FREEBOARD OF SHELTER-DECKED STEAMERS

By the term "shelter-decked steamer" is meant, for the purpose of the following instructions, a steam vessel having a complete superstructure of a substantial character extending over the whole length of the vessel, the superstructure deck (hereinafter called the shelter-deck) being continuous and unbroken at the sides of the vessel, but having one or more openings at the middle line, which have no permanent means of closing them, but which may not have means for temporarily closing them.

All hatchways in the deck immediately below the shelter-deck should be properly framed with substantial coamings, hatch covers, and shifting beams, etc., as described in paragraph 24. The hatchways should have efficient means of battening down as described in clause 7 of these rules and any stairways or similar openings should have efficient means of closing.

In assigning freeboards to shelter-decked vessels, the following rules should be observed:

(1) In making the sheer correction in accordance with para. 18 of the load-line tables, the sheer is to be measured at the ends of the vessel, and the freeboard corrected for sheer in estimating the allowance for erections.

(2). (*a*) In the case of shelter-decked vessels having only one opening in the shelter-deck, the length correction under para. 9 of the load-line tables is to be one-half that specified in Table A; and the allowance for deck erections is to be determined under para. 11 in the manner specified below, provided that the effective length of the deck erections, when assessed on the assumption that the opening in the deck is an open well, and in accordance with the different regulations contained in the load-line tables affecting poops, bridges, and forecastle, open or closed, is not less than $\frac{6}{10}$ of the length of the vessel.

(*b*) In the case of shelter-decked vessels having an opening at each end of the vessel, and also in the case of vessels having more than two openings in the shelter-deck, the allowance for deck erections is to be determined under para. 12 of the tables, the length correction under para. 9 of the load-line tables is to be one-half that specified in Table A, provided that the effective length of the deck erections, when assessed on the assumption that each opening in the deck is an open well, and in accordance with the different regulations contained in the load-line tables

affecting poops, bridges, and forecastles, open or closed, is not less than $\frac{6}{10}$ of the length of the vessel.

(3) The effective length of the deck erections is to be calculated in the following manner, provided the openings in the shelter-deck do not exceed half the vessel's breadth at the middle of the length of the opening. The length to be taken in the first instance as if each opening were an open well, the value of each part being assessed on that assumption in accordance with the different regulations contained in the load-line tables affecting poops, bridge-houses, and forecastles, open or closed, and also in accordance with the regulations regarding bridge-houses not covering the engine and boiler space. The final allowance for erections will depend upon whether or not temporary but efficient means are provided for closing the openings in the shelter-deck.

(*a*) If efficient means as specified below are provided for temporarily closing the openings in the shelter-deck, the effective length of the deck erections is to be reckoned as the length computed as prescribed above, plus half the difference between that length and the length of the vessel.

(*b*) If efficient means for temporarily closing the openings are not provided, the effective length of the erections is to be computed by adding to the length computed as above one-fourth, instead of one-half, the difference between that length and the length of the vessel.

(*c*) If the openings in the shelter-deck are wider than as specified above, the addition to the assumed length of erections is to be modified in proportion to the relation which the actual opening holds to the specified breadth and to a complete well.

4. Means for temporarily closing the openings in the shelter-deck may be regarded as efficient, if they are at least equivalent to the following in strength and security. The portable planks for closing the openings to be not less in thickness than required by para. 43 of Lloyd's Rules (1885) for the flat of awning-decks. The planks to be supported by portable beams, fitted either longitudinally or athwartships, spaced not wider than 5 feet apart, and efficiently secured at their ends, and the deck in way of the openings to be efficiently supported by pillars from the deck below. The portable planks to be provided with eye bolts and lashings, or some other equally efficient means of securing them in place.

5. If efficient means are provided for temporarily closing the openings in the shelter-deck in heavy weather, the freeing ports required by para. 11 (*e*) need not be provided. If, however, efficient means for closing the openings are not provided, whether in vessels with one or more than one opening in the shelter-

k, then freeing ports with shutters properly hung are to be ɜd, having a minimum area as follows:

Length of Opening in the Shelter-deck, Feet.	Freeing Port Area on Each Side in Square Feet.
5	4.5
10	6.5
15	7.5
20	8.5
25	9.0

f the freeing port area is less than that stated above, an lition is to be made to the freeboard of ½ per cent of the vessel's ulded depth, provided, however, that in the case of vessels ated under para. 12, the freeboard is not to be increased be- ıd that due to deck erections of the same length and character, t with open wells, as determined by the different regulations ıtained in the load-line tables affecting poops, bridge-houses, l forecastles.

ʖ. The deduction for summer to be intermediate between bles A and C, in proportion to the effective length of erections ally allowed for freeboard purposes, and the freeboards igned to those vessels must never be less than would be igned for a complete awning-decked vessel of the same dimen- ns.

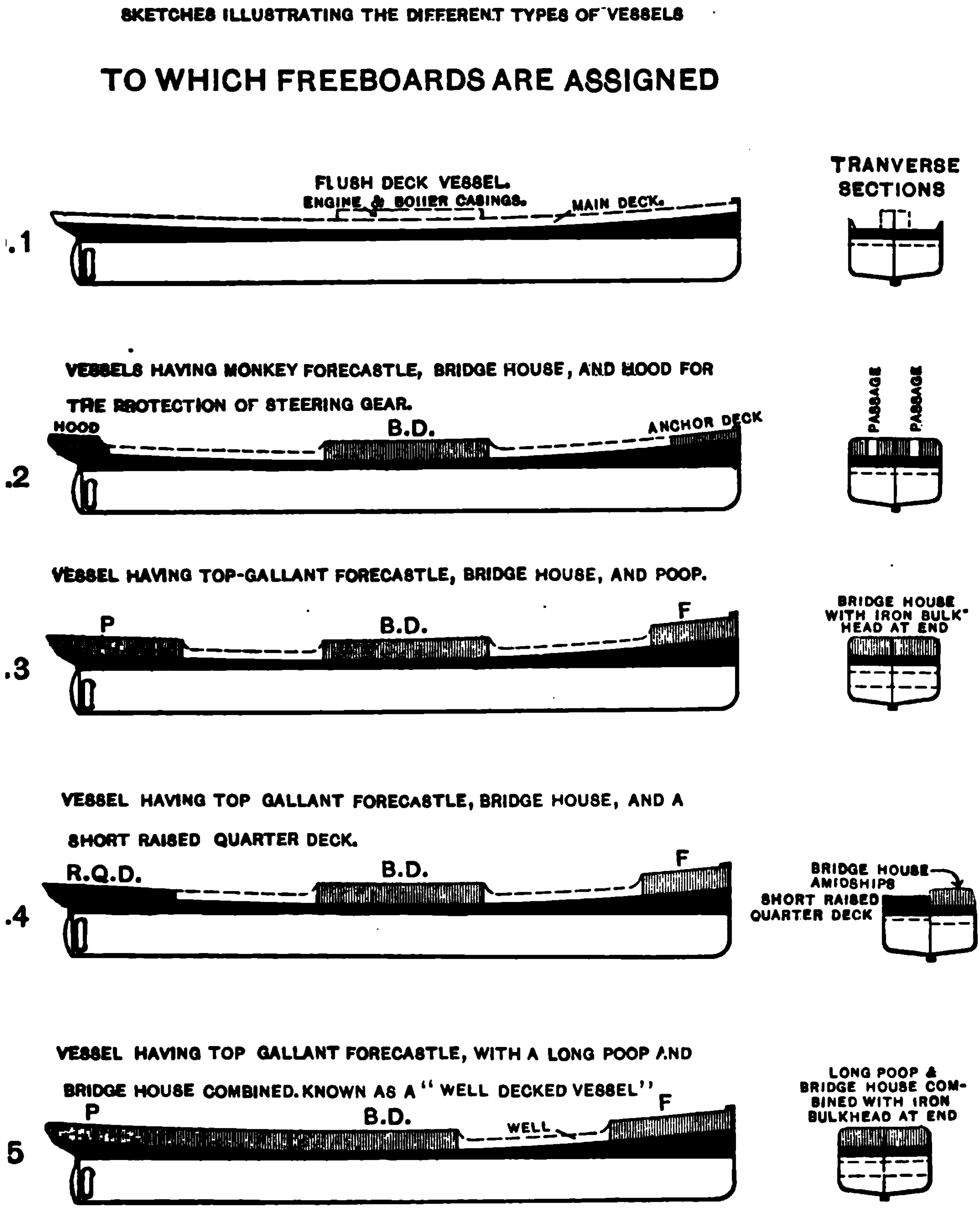
7. For the purpose of the assignment of freeboards, a hatch- y having strong iron or steel coamings, with hatch rest bars the usual description, and also cleats for battening down bars urely riveted to the coamings, thwartship beams and fore l afters, substantial hatch covers and tarpaulins, shall be con- ered to have "permanent means of closing." And a deck ction having no openings in it, except so protected, shall be d to be "permanently enclosed."

'he above reduction in freeboard for summer voyages from European and literranean ports is to be made from April to September inclusive. In other ts of the world the reduced freeboard shall be used during the corresponding recognised summer months. Double the above reduction to be allowed for 'ages in the fine season in the Indian seas, between the limits of Suez and gapore. An additional freeboard of two inches should be required for all sels up to and including 330 feet in length when entering the North Atlantic, ɔn sailing to, or from, the Mediterranean, or any British or European port, l which may sail to, or from, or call at, ports in British North America, or ern ports in the United States, north of Cape Hatteras, from October to rch inclusive.

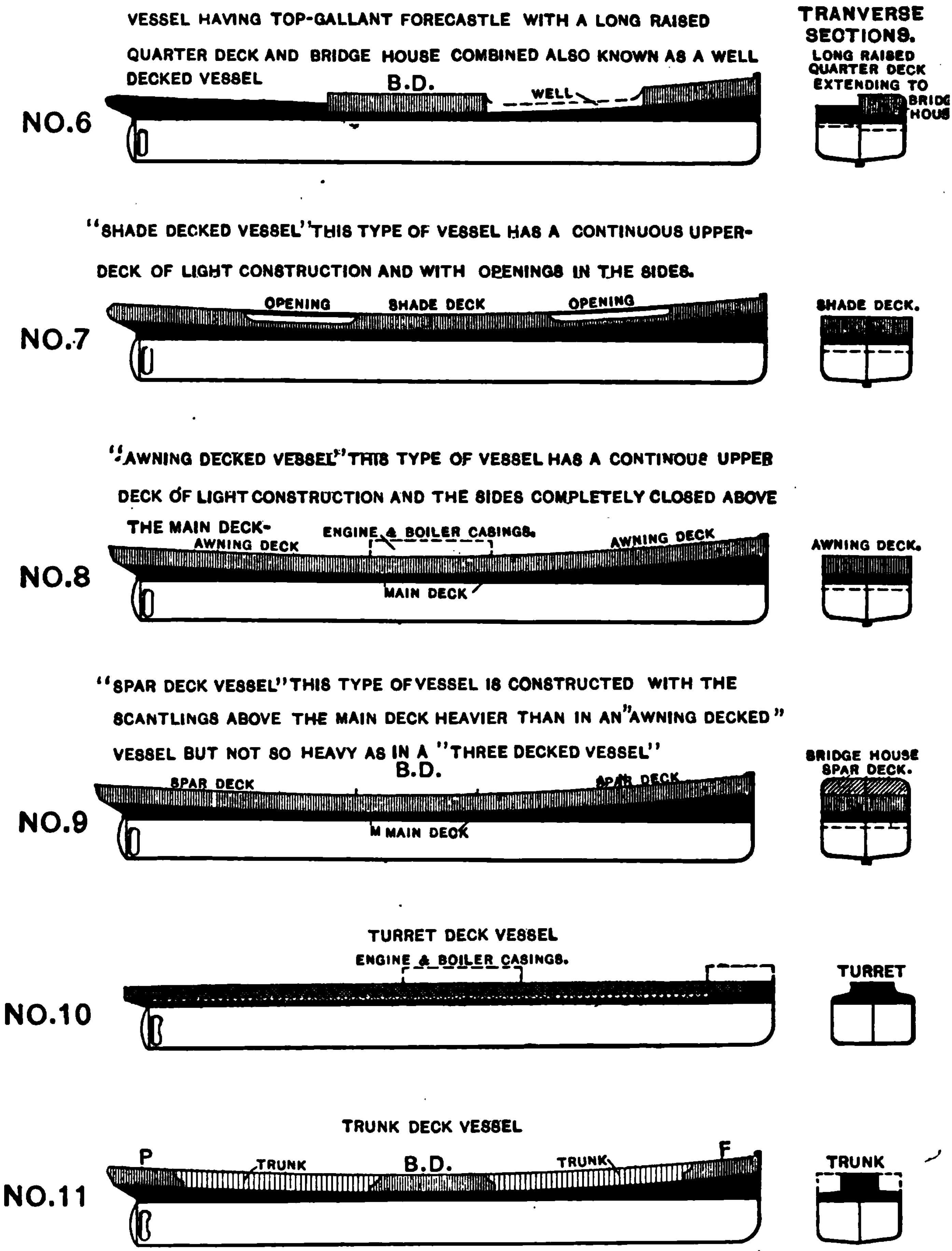
Load Draught Diagrams.

(Based on British Freeboard Tables.)

It is often necessary to get an approximation to the load draught in estimating on proposed vessels, when in many cases there is insufficient time to calculate the freeboard in the regular way. For this purpose the adjoining diagrams have been prepared for cargo vessels from the freeboard tables, and from these the mean moulded load draught may be scaled off with accuracy, always observing that the proper allowances for excess of sheer, erections on deck, and uncovered iron deck, strength, etc., must be made afterwards. These diagrams being graphic reproductions of the various tables, will be found to facilitate the estimating of load draughts where a sufficiently close approximation only is required. It should also be borne in mind that fullness of form influences the freeboard to a considerable extent, therefore the diagram will only read correctly for vessels having coefficients of under deck tonnage from .78 to .82, and judgment must be used when dealing with vessels of finer forms, the freeboards of which are less than in the case of fuller vessels.


SKETCHES ILLUSTRATING THE DIFFERENT TYPES OF VESSELS
TO WHICH FREEBOARDS ARE ASSIGNED
TRANVERSE SECTIONS
FLUSH DECK VESSEL.
ENGINE & BOILER CASINGS.
MAIN DECK.
.1
VESSELS HAVING MONKEY FORECASTLE, BRIDGE HOUSE, AND HOOD FOR THE PROTECTION OF STEERING GEAR.
HOOD
B.D.
ANCHOR DECK
PASSAGE
PASSAGE
.2
VESSEL HAVING TOP-GALLANT FORECASTLE, BRIDGE HOUSE, AND POOP.
P
B.D.
F
BRIDGE HOUSE WITH IRON BULK-HEAD AT END
.3
VESSEL HAVING TOP GALLANT FORECASTLE, BRIDGE HOUSE, AND A SHORT RAISED QUARTER DECK.
R.Q.D.
B.D.
F
BRIDGE HOUSE AMIDSHIPS
SHORT RAISED QUARTER DECK
.4
VESSEL HAVING TOP GALLANT FORECASTLE, WITH A LONG POOP AND BRIDGE HOUSE COMBINED. KNOWN AS A "WELL DECKED VESSEL"
P
B.D.
WELL
F
LONG POOP & BRIDGE HOUSE COMBINED WITH IRON BULKHEAD AT END
5

Figs. 18-22.

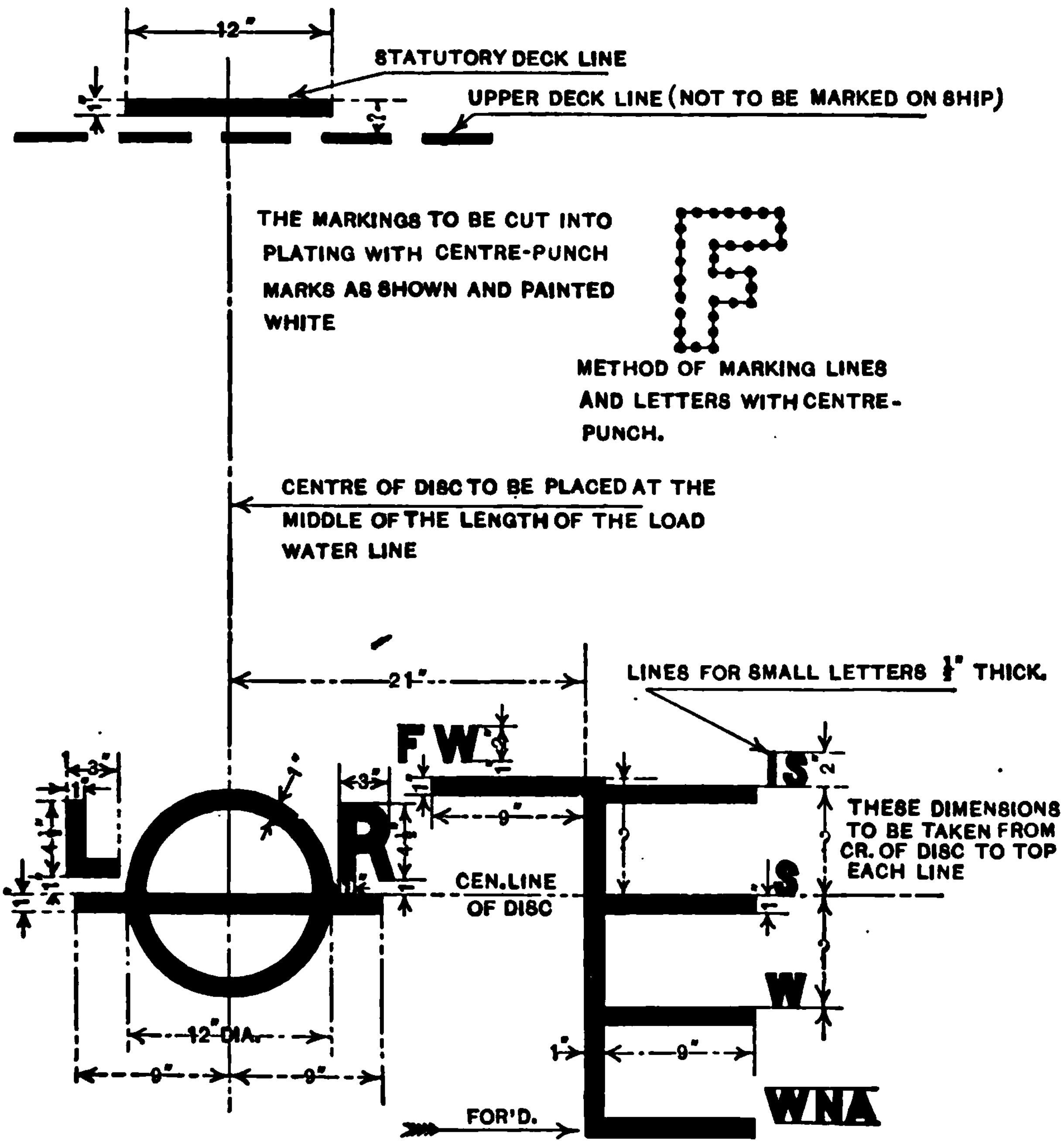

TRANVERSE SECTIONS.
VESSEL HAVING TOP-GALLANT FORECASTLE WITH A LONG RAISED QUARTER DECK AND BRIDGE HOUSE COMBINED ALSO KNOWN AS A WELL DECKED VESSEL
B.D.
WELL
NO.6
LONG RAISED QUARTER DECK EXTENDING TO BRIDGE HOUSE
"SHADE DECKED VESSEL" THIS TYPE OF VESSEL HAS A CONTINUOUS UPPER-DECK OF LIGHT CONSTRUCTION AND WITH OPENINGS IN THE SIDES.
OPENING
SHADE DECK
OPENING
NO.7
SHADE DECK.
"AWNING DECKED VESSEL" THIS TYPE OF VESSEL HAS A CONTINOUS UPPER DECK OF LIGHT CONSTRUCTION AND THE SIDES COMPLETELY CLOSED ABOVE THE MAIN DECK-
ENGINE & BOILER CASINGS.
AWNING DECK
AWNING DECK
MAIN DECK
NO.8
AWNING DECK.
"SPAR DECK VESSEL" THIS TYPE OF VESSEL IS CONSTRUCTED WITH THE SCANTLINGS ABOVE THE MAIN DECK HEAVIER THAN IN AN "AWNING DECKED" VESSEL BUT NOT SO HEAVY AS IN A "THREE DECKED VESSEL"
B.D.
SPAR DECK
SPAR DECK
MAIN DECK
NO.9
BRIDGE HOUSE
SPAR DECK.
TURRET DECK VESSEL
ENGINE & BOILER CASINGS.
NO.10
TURRET
TRUNK DECK VESSEL
P
TRUNK
B.D.
TRUNK
F
NO.11
TRUNK

FIGS. 23–28.

Statutory allowance above top of wood deck $= 2''$
Centre of disc below statutory deck line $= 6' \ 7\frac{1}{2}''$
Draught of water moulded $= 26' \ 10\frac{1}{2}''$

DIAGRAM OF FREEBOARD MARKS FOR STEAMERS.

(FOR FREEBOARD SEE TABLES)



ST'B'D. SIDE SHOWN- PORT SIDE SIMILAR

FIG. 30.

(Fig. 29 in this edition has been omitted.)

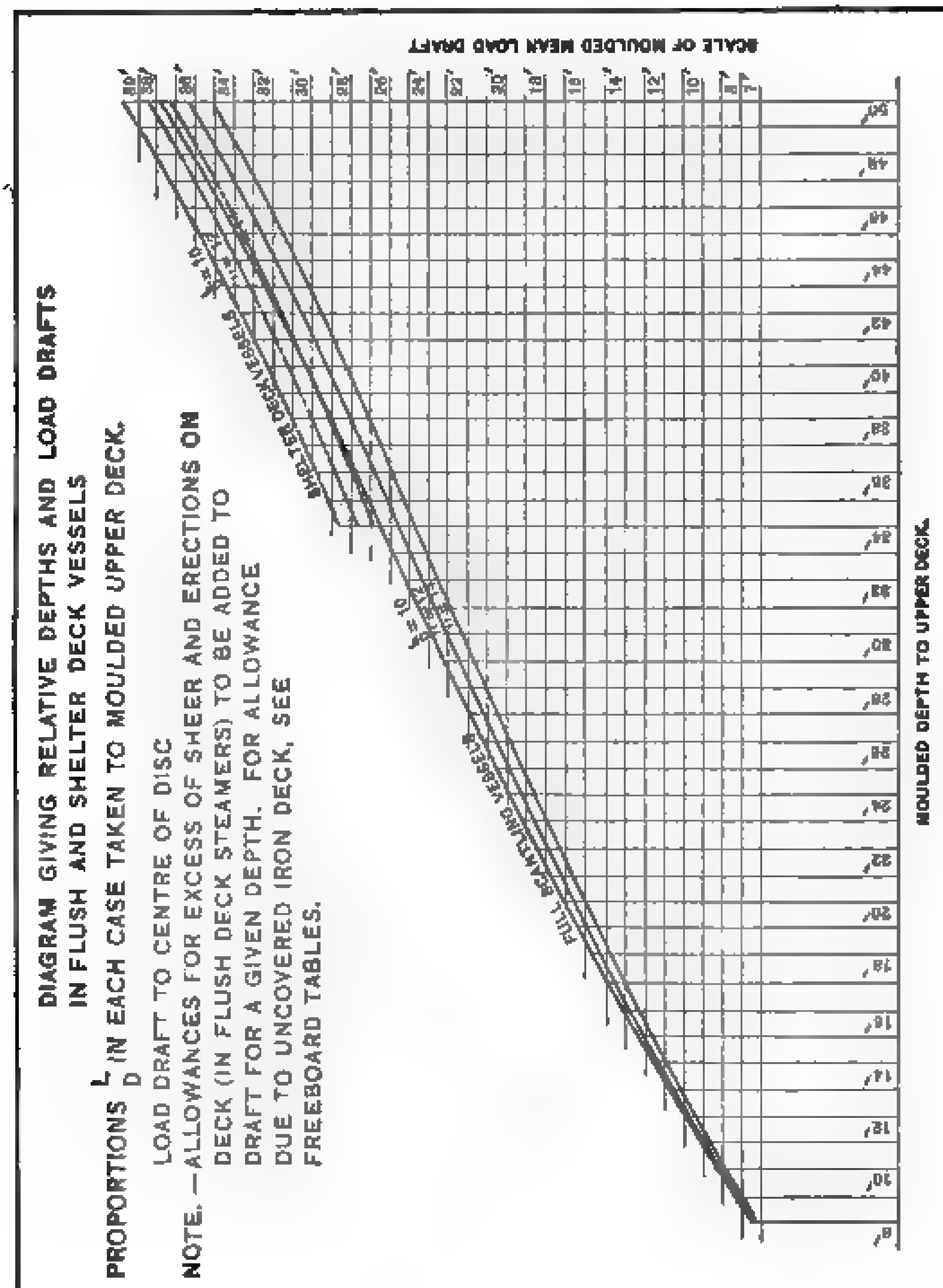


DIAGRAM GIVING RELATIVE DEPTHS AND LOAD DRAFTS
IN FLUSH AND SHELTER DECK VESSELS
PROPORTIONS L/D IN EACH CASE TAKEN TO MOULDED UPPER DECK.
LOAD DRAFT TO CENTRE OF DISC
NOTE.—ALLOWANCES FOR EXCESS OF SHEER AND ERECTIONS ON
DECK (IN FLUSH DECK STEAMERS) TO BE ADDED TO
DRAFT FOR A GIVEN DEPTH. FOR ALLOWANCE
DUE TO UNCOVERED IRON DECK, SEE
FREEBOARD TABLES.
SCALE OF MOULDED MEAN LOAD DRAFT
MOULDED DEPTH TO UPPER DECK.
SHELTER DECK VESSELS
FULL SCANTLING VESSELS

Fig. 31.

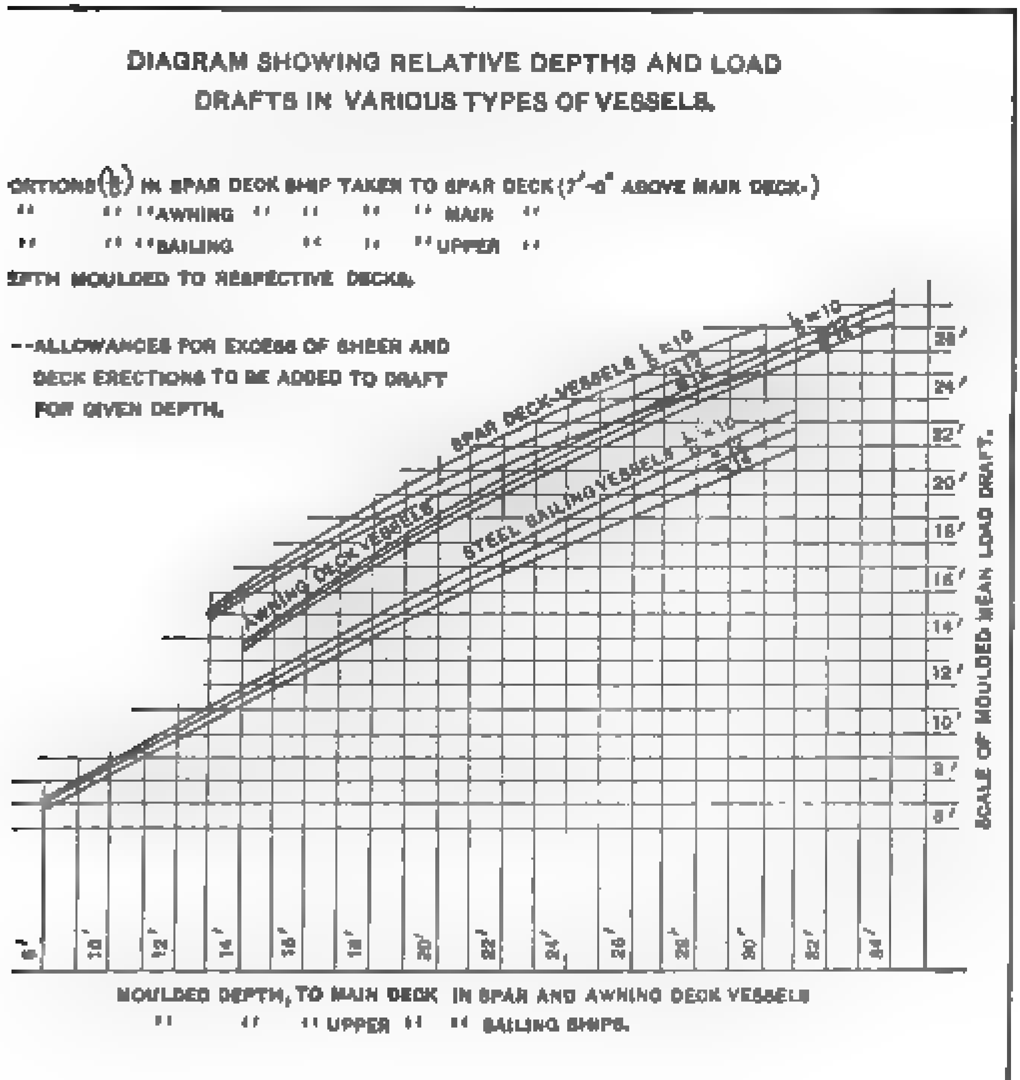


DIAGRAM SHOWING RELATIVE DEPTHS AND LOAD DRAFTS IN VARIOUS TYPES OF VESSELS.
ORTIONS (L/D) IN SPAR DECK SHIP TAKEN TO SPAR DECK (7'-0" ABOVE MAIN DECK.)
" " "AWNING " " " " MAIN "
" " "SAILING " " " UPPER "
EPTH MOULDED TO RESPECTIVE DECKS.
--ALLOWANCES FOR EXCESS OF SHEER AND DECK ERECTIONS TO BE ADDED TO DRAFT FOR GIVEN DEPTH.
SPAR DECK VESSELS
AWNING DECK VESSELS
STEEL SAILING VESSELS
SCALE OF MOULDED MEAN LOAD DRAFT.
MOULDED DEPTH, TO MAIN DECK IN SPAR AND AWNING DECK VESSELS
" " " UPPER " " SAILING SHIPS.

FIG. 32.

Table A.

Cargo-carrying Steam Vessels Not Having Spar or Awning Decks.

Table of Reserve Buoyancy and Freeboard for First-class Sea-going Iron and Steel Steam Vessels (in Salt Water).

Coefficient of Fineness.	Percentage Reserve Buoyancy (Winter).							
	20.4	20.6	20.8	21.0	21.2	21.4	21.6	21.8
	Corresponding Height of Freeboard Amidships (Winter). Measured from Top of Deck at Sides.							
	Moulded Depth and Length.							
	′ ″ 6 0	′ ″ 6 6	′ ″ 7 0	′ ″ 7 6	′ ″ 8 0	′ ″ 8 6	′ ″ 9 0	′ ″ 9 6
	′ 72	′ 78	′ 84	′ 90	′ 96	′ 102	′ 108	′ 114
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
0.68	0 8	0 9	0 10	0 11	1 0	1 1	1 2	1 3
0.70	0 8	0 9	0 10	0 11	1 0	1 1	1 2	1 3
0.72	0 8½	0 9½	0 10½	0 11½	1 0½	1 1½	1 2½	1 3½
0.74	0 8½	0 9½	0 10½	0 11½	1 0½	1 1½	1 2½	1 3½
0.76	0 9	0 10	0 11	1 0	1 1	1 2	1 3	1 4
0.78	0 9½	0 10	0 11	1 0	1 1	1 2	1 3	1 4
0.80	0 9	0 10½	0 11½	1 0½	1 1½	1 2½	1 3½	1 4½
0.82	0 9½	0 10½	0 11½	1 0½	1 1½	1 2½	1 3½	1 4½
Correction in inches for a change of 10′ in the length.	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8
Deductions in ins. for summer voyages.	1	1	1	1	1	1	1	1

Table A. — (*Continued.*)

Cargo-carrying Steam Vessels Not Having Spar or Awning Decks.

Table of Reserve Buoyancy and Freeboard for First-class Sea-going Iron and Steel Steam Vessels (in Salt Water).

Coefficient of Fineness.	Percentage Reserve Buoyancy (Winter).															
	22.0		22.2		22.4		22.6		22.8		23.0		23.2		23.4	
	Corresponding Height of Freeboard Amidships (Winter). Measured from Top of Deck at Side.															
	Moulded Depth and Length.															
	′	″	′	″	′	″	′	″	′	″	′	″	′	″	′	″
	10	0	10	6	11	0	11	6	12	0	12	6	13	0	13	6
	′ 120		′ 126		′ 132		′ 138		′ 144		′ 150		′ 156		′ 162	
	′	″	′	″	′	″	′	″	′	″	′	″	′	″	′	″
0.68	1	4	1	5	1	6	1	7½	1	8½	1	9½	1	11	2	0
0.70	1	4	1	5	1	6	1	7½	1	8½	1	9½	1	11	2	0½
0.72	1	4½	1	5½	1	6½	1	8	1	9	1	10	1	11½	2	1
0.74	1	4½	1	5½	1	6½	1	8	1	9	1	10	1	11½	2	1
0.76	1	5	1	6	1	7	1	8½	1	9½	1	10½	2	0	2	1½
0.78	1	5	1	6	1	7	1	8½	1	9½	1	11	2	0½	2	2
0.80	1	5½	1	6½	1	7½	1	9	1	10	1	11½	2	1	2	2½
0.82	1	5½	1	6½	1	7½	1	9	1	10	1	11½	2	1	2	2½
Correction in ins. for a change of 10′ in the length.	0.8		0.9		0.9		0.9		0.9		0.9		0.9		0.9	
Deductions in ins. for summer voyages.	1		1		1		1		1		1		1		1½	

Table A. — (*Continued.*)

Cargo-carrying Steam Vessels Not Having Spar or Awning Decks.

Table of Reserve Buoyancy and Freeboard for First-class Sea-going Iron and Steel Steam Vessels (in Salt Water).

Coefficient of Fineness.	Percentage Reserve Buoyancy (Winter).					
	23.6	23.8	24.0	24.2	24.5	24.7
	Corresponding Height of Freeboard Amidships (Winter). Measured from Top of Deck at Side.					
	Moulded Depth and Length.					
	14′ 0″	14′ 6″	15′ 0″	15′ 6″	16′ 0″	16′ 6″
	168′	174′	180′	186′	192′	198′
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
0.68	2 1½	2 3	2 4	2 5½	2 7	2 8½
0.70	2 1½	2 3	2 4½	2 6	2 7½	2 9
0.72	2 2	2 3½	2 5	2 6½	2 8	2 9½
0.74	2 2½	2 4	2 5½	2 7	2 8½	2 10
0.76	2 3	2 4½	2 6	2 7½	2 9	2 10½
0.78	2 3	2 4½	2 6	2 7½	2 9	2 11
0.80	2 3½	2 5	2 6½	2 8	2 9½	2 11½
0.82	2 4	2 5½	2 7	2 8½	2 10	3 0
Correction in ins. for a change of 10′ in the length.	1.0	1.0	1.0	1.0	1.0	1.0
Deduction in ins. for summer voyages.	1½	1½	1½	1½	1½	2

Table A. — (*Continued.*)

Cargo-carrying Steam Vessels Not Having Spar or Awning Decks.

Table of Reserve Buoyancy and Freeboard for First-class Sea-going Iron and Steel Steam Vessels (in Salt Water).

Coefficient of Fineness.	Percentage Reserve Buoyancy (Winter)				
	25.0	25.2	25.5	25.7	26.0
	Corresponding Height of Freeboard Amidships (Winter). Measured from Top of Deck at Side.				
	Moulded Depth and Length.				
	17′ 0″	17′ 6″	18′ 0″	18′ 6″	19′ 0″
	204′	210′	216′	222′	228′
	′ ″	′ ″	′ ″	′ ″	′ ″
0.68	2 10½	2 11½	3 1	3 2½	3 4
0.70	2 10	3 0	3 1½	3 3	3 4½
0.72	2 11	3 0½	3 2	3 3½	3 5½
0.74	2 11½	3 1	3 2½	3 4	3 6
0.76	3 0	3 1½	3 3	3 5	3 6½
0.78	3 0½	3 2	3 4	3 5½	3 7½
0.80	3 1	3 2½	3 4½	3 6	3 8
0.82	3 1½	3 3	3 5	3 6½	3 8½
orrection in ins. for a change of 10′ in the length.	1.1	1.1	1.1	1.1	1.1
eduction in ins. for summer voyages.	2	2	2	2	2

Table A. — (*Continued.*)

Cargo-carrying Steam Vessels Not Having Spar or Awning Decks.

Table of Reserve Buoyancy and Freeboard for First-class Sea-going Iron and Steel Steam Vessels (in Salt Water).

Coefficient of Fineness.	Percentage Reserve Buoyancy (Winter).					
	26.2	26.5	26.7	27.0	27.3	27.5
	Corresponding Height of Freeboard Amidships (Winter). Measured from Top of Deck at Side.					
	Moulded Depth and Length.					
	19' 6"	20' 0"	20' 6"	21' 0"	21' 6"	22' 0"
	234'	240'	246'	252'	258'	264'
	' "	' "	' "	' "	' "	' "
0.68	3 5½	3 7½	3 9	3 11½	4 0½	4 2½
0.70	3 6½	3 8	3 10	3 11½	4 1½	4 3½
0.72	3 7	3 8½	3 10½	4 0	4 2	4 4
0.74	3 8	3 9½	3 11½	4 1	4 3	4 5
0.76	3 8½	3 10	4 0	4 1½	4 3½	4 5½
0.78	3 9½	3 11	4 1	4 2½	4 4½	4 6½
0.80	3 10	3 11½	4 1½	4 3	4 5	4 7
0.82	3 10½	4 0	4 2	4 3½	4 5½	4 7½
Correction in ins. for a change of 10' in the length.	1.1	1.2	1.2	1.2	1.2	1.2
Deduction in ins. for summer voyages.	2½	2½	2½	2½	2½	2½

Table A. — (*Continued.*)

Cargo-carrying Steam Vessels Not Having Spar or Awning Decks.

Table of Reserve Buoyancy and Freeboard for First-class Sea-going Iron and Steel Steam Vessels (in Salt Water).

Coefficient of Fineness.	Percentage Reserve Buoyancy (Winter).					
	27.8	28.1	28.3	28.6	28.9	29.2
	Corresponding Height of Freeboard Amidships (Winter). Measured from Top of Deck at Side.					
	Moulded Depth and Length.					
	22′ 6″	23′ 0″	23′ 6″	24′ 0″	24′ 6″	25′ 0″
	270′	276′	282′	288′	294′	300′
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
0.68	4 4½	4 6½	4 8½	4 10½	5 1	5 3½
0.70	4 5½	4 7½	4 9½	4 11½	5 1½	5 4
0.72	4 6	4 8	4 10	5 0	5 2½	5 5
0.74	4 7	4 9	4 11	5 1	5 3	5 5½
0.76	4 7½	4 9½	4 11½	5 1½	5 4	5 6½
0.78	4 8½	4 10½	5 0½	5 2½	5 4½	5 7
0.80	4 9	4 11	5 1	5 3	5 5½	5 8
0.82	4 9½	4 11½	5 2	5 4	5 6½	5 9
Correction in ins. for a change of 10′ in the length.	1.2	1.2	1.3	1.3	1.3	1.3
Deduction in ins. for summer voyages.	3	3	3	3	3	3½

Table A. — (*Continued.*)

Cargo-carrying Steam Vessels Not Having Spar or Awning Decks.

Table of Reserve Buoyancy and Freeboard for First-class Sea-going Iron and Steel Steam Vessels (in Salt Water).

Coefficient of Fineness.	Percentage Reserve Buoyancy (Winter).					
	29.5	29.8	30.1	30.4	30.8	31.1
	Corresponding Height of Freeboard Amidships (Winter). Measured from Top of Deck at Side.					
	Moulded Depth and Length.					
	25′ 6″	26′ 0″	26′ 6″	27′ 0″	27′ 6″	28′ 0″
	306′	312′	318′	324′	330′	336′
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
0.68	5 5½	5 8	5 10	6 0½	6 3	6 5
0.70	5 6	5 8½	5 10½	6 1	6 3½	6 6
0.72	5 7	5 9½	5 11½	6 2	6 4½	6 7
0.74	5 7½	5 10	6 0½	6 3	6 5½	6 8
0.76	5 8½	5 11	6 1½	6 4	6 6½	6 9
0.78	5 9	5 11½	6 2	6 4½	6 7	6 9½
0.80	5 10	6 0½	6 3	6 5½	6 8	6 10½
0.82	5 11	6 1½	6 4	6 6½	6 9	6 11½
Correction in ins. for a change of 10′ in the length.	1.3	1.4	1.4	1.4	1.4	1.4
Deduction in ins. for summer voyages.	3½	3½	3½	4	4	4

Table A. — (*Continued.*)

Cargo-carrying Steam Vessels Not Having Spar or Awning Decks.

ble of Reserve Buoyancy and Freeboard for First-class Sea-going Iron and Steel Steam Vessels (in Salt Water).

Coefficient of Fineness.	Percentage Reserve Buoyancy (Winter).					
	31.3	31.5	31.8	32.0	32.3	32.6
	Corresponding Height of Freeboard Amidships (Winter). Measured from Top of Deck at Side.					
	Moulded Depth and Length.					
	′ ″ 28 6	′ ″ 29 0	′ ″ 29 6	′ ″ 30 0	′ ″ 30 6	′ ″ 31 0
	′ 342	′ 348	′ 354	′ 360	′ 366	′ 372
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
0.68	6 7	6 9	6 11	7 1½	7 4	7 6½
0.70	6 8	6 10½	7 0½	7 3	7 5½	7 8
0.72	6 9	6 11½	7 1½	7 4	7 6½	7 9
0.74	6 10	7 0½	7 2½	7 5	7 7½	7 10
0.76	6 11	7 1½	7 3½	7 6	7 8½	7 11
0.78	7 0	7 2½	7 5	7 7½	7 10	8 0½
0.80	7 1	7 3½	7 6	7 8½	7 11	8 1½
0.82	7 2	7 4½	7 7	7 9½	8 0	8 2½
rection in ins. a change of in the length.	1.5	1.5	1.5	1.5	1.5	1.6
luction in ins. summer yages.	4	4½	4½	4½	5	5

Table A. — (*Continued.*)

Cargo-carrying Steam Vessels Not Having Spar or Awning Decks.

Table of Reserve Buoyancy and Freeboard for First-class Sea-going Iron and Steel Steam Vessels (in Salt Water).

Coefficient of Fineness.	Percentage Reserve Buoyancy (Winter).					
	32.8	33.0	33.3	33.5	33.8	34.0
	Corresponding Height of Freeboard Amidships (Winter). Measured from Top of Deck at Side.					
	Moulded Depth and Length.					
	′ ″ 31 6	′ ″ 32 0	′ ″ 32 6	′ ″ 33 0	′ ″ 33 6	′ ″ 34 0
	′ 378	′ 384	′ 390	′ 396	′ 402	′ 408
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
0.68	7 9	7 11½	8 1½	8 4	8 6½	8 9
0.70	7 10½	8 1	8 3	8 5½	8 8	8 10½
0.72	7 11½	8 2	8 4	8 6½	8 9	8 11½
0.74	8 0½	8 3	8 5½	8 8	8 10½	9 1
0.76	8 1½	8 4	8 6½	8 9	8 11½	9 2
0.78	8 3	8 5½	8 8	8 10½	9 1	9 3½
0.80	8 4	8 6½	8 9	8 11½	9 2	9 4½
0.82	8 5	8 7½	8 10	9 0½	9 3	9 5½
Correction in ins. for a change of 10′ in the length.	1.6	1.6	1.6	1.6	1.7	1.7
Deduction in ins. for summer voyages.	5	5	5½	5½	5½	6

Table A. — (*Continued.*)

Cargo-carrying Steam Vessels Not Having Spar or Awning Decks.

Table of Reserve Buoyancy and Freeboard for First-class Sea-going Iron and Steel Steam Vessels (in Salt Water).

Coefficient of Fineness.	Percentage Reserve Buoyancy (Winter).							
	34.2	34.4	34.6	34.7	34.9	35.1	35.3	35.4
	Corresponding Height of Freeboard Amidships (Winter). Measured from Top of Deck at Side.							
	Moulded Depth and Length.							
	34′ 6″	35′ 0″	35′ 6″	36′ 0″	36′ 6″	37′ 0″	37′ 6″	38′ 0″
	414′	420′	426′	432′	438′	444′	450′	456′
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
0.68	8 11½	9 2	9 4	9 6	9 8½	9 11	10 1½	10 3½
0.70	9 1	9 3	9 5	9 7	9 9½	10 0	10 2½	10 5
0.72	9 2	9 4	9 6½	9 8½	9 11	10 1½	10 4	10 6½
0.74	9 3½	9 5½	9 8	9 10	10 0½	10 3	10 5½	10 8
0.76	9 4½	9 7½	9 9	9 11½	10 2	10 4½	10 7½	10 9½
0.78	9 6	9 8	9 10½	10 0½	10 3	10 5½	10 8	10 10½
0.80	9 7	9 9½	9 11½	10 2	10 4½	10 7	10 9½	11 0
0.82	9 8	9 10½	10 1	10 3½	10 6	10 8½	10 11	11 1½
Correction in ins. for a change of 10′ in the length.	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Deduction in ins. for summer voyages.	6	6	6	6½	6½	6½	6½	7

Table A. — (*Continued.*)

Cargo-carrying Steam Vessels Not Having Spar or Awning Decks.

Table of Reserve Buoyancy and Freeboard for First-class Sea-going Iron and Steel Steam Vessels (in Salt Water).

Coefficient of Fineness.	Percentage Reserve Buoyancy (Winter)							
	35.4	35.5	35.6	35.6	35.7	35.7	35.8	35.8
	Corresponding Height of Freeboard Amidships (Winter). Measured from Top of Deck at Side.							
	Moulded Depth and Length.							
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
	38 6	39 0	39 6	40 0	40 6	41 0	41 6	42 0
	′	′	′	′	′	′	′	′
	462	468	474	480	486	492	498	504
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
0.68	10 5½	10 7½	10 9½	10 11½	11 1½	11 3½	11 6	11 8
0.70	10 7	10 9	10 11	11 1	11 3	11 5	11 7½	11 9½
0.72	10 8½	10 10½	11 0½	11 2½	11 4½	11 6½	11 9	11 11
0.74	10 10	11 0	11 2	11 4	11 6	11 8	11 10½	12 0½
0.76	11 11½	11 1½	11 3½	11 5½	11 7½	11 9½	12 0	12 2
0.78	11 0½	11 2½	11 4½	11 7	11 9	11 11	12 1½	12 3½
0.80	11 2	11 4	11 6	11 8½	11 10½	12 0½	12 3	12 5
0.82	11 3½	11 5½	11 7½	11 10	12 0	12 2½	12 5	12 7
Correction in ins. for a change of 10′ in the length.	1.7	1.7	1.7	1.7	1.7	1.7	1,7	1.7
Deduction in ins. for summer voyages.	7	7	7	7½	7½	7½	7½	8

Table A. — (*Continued.*)

Cargo-carrying Steam Vessels Not Having Spar or Awning Decks.

Table of Reserve Buoyancy and Freeboard for First-class Sea-going Iron and Steel Steam Vessels (in Salt Water).

Coefficient of Fineness.	Percentage Reserve Buoyancy (Winter).							
	35.8	35.8	35.8	35.8	35.8	35.8	35.8	35.8
	Corresponding Height of Freeboard Amidships (Winter). Measured from Top of Deck at Side.							
	Moulded Depth and Length.							
	′ ″ 42 6	′ ″ 43 0	′ ″ 43 6	′ ″ 44 0	′ ″ 44 6	′ ″ 45 0	′ ″ 45 6	′ ″ 46 0
	′ 510	′ 516	′ 522	′ 528	′ 534	′ 540	′ 546	′ 552
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ′	′ ″
0.68	11 10½	12 0	12 2	12 3½	12 5	12 7	12 9	12 10½
0.70	12 0	12 2	12 4	12 5½	12 7	12 8½	12 10½	13 0
0.72	12 1½	12 3½	12 5½	12 7	12 8½	12 10	13 0	13 2
0.74	12 3	12 5	12 7	12 8½	12 10	13 0	13 2	13 4
0.76	12 4½	12 6½	12 8½	12 10	13 0	13 2	13 4	13 6
0.78	12 6	12 8	12 10	13 0	13 2	13 3½	13 5½	13 7½
0.80	12 7½	12 9½	12 11½	13 1½	13 3½	13 5	13 7	13 9
0.82	12 9½	12 11½	13 1½	13 3½	13 5½	13 7	13 9	13 10½
Correction in ins. for a change of 10′ in the length.	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Deduction in ins. for summer voyages.	8	8	8	8½	8½	8½	8½	9

Table A. — (*Continued.*)

Cargo-carrying Steam Vessels Not Having Spar or Awning Decks.

Table of Reserve Buoyancy and Freeboard for First-class Sea-going Iron and Steel Steam Vessels (in Salt Water).

Coefficient of Fineness.	Percentage of Reserve Buoyancy (Winter).							
	35.8	35.8	35.8	35.8	35.8	35.8	35.8	35.8
	Corresponding Height of Freeboard Amidships (Winter). Measured from Top of Deck at Side.							
	Moulded Depth and Length.							
	46' 6"	47' 0"	47' 6"	48' 0"	48' 6"	49' 0"	49' 6"	50' 0"
	558'	564'	570'	576'	582'	588'	594'	600'
	' "	' "	' "	' "	' "	' "	' "	' "
0.68	13 0	13 1½	13 3	13 5	13 6½	13 8	13 9½	13 11
0.70	13 1½	13 3	13 4½	13 6½	13 8	13 10	13 11½	14 1
0.72	13 3½	13 5	13 6½	13 8½	13 10	13 11½	14 1	14 3
0.74	13 5½	13 7	13 8½	13 10½	14 0	14 1½	14 3	14 4½
0.76	13 7½	13 9	13 10½	14 0½	14 2	14 3½	14 5	14 6½
0.78	13 9	13 10½	14 0	14 2	14 3½	14 5	14 6½	14 8½
0.80	13 10½	14 0	14 1½	14 3½	14 5	14 6½	14 8	14 10
0.82	14 0½	14 2	14 3½	14 5½	14 7	14 8½	14 10	15 0
Correction in ins. for a change of 10' in the length.	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Deduction in ins. for summer voyages.	9	9	9	9½	9½	9½	9½	9½

Table B.

Cargo-carrying Spar Deck Vessels.

Table of Freeboard to Spar Deck for First-class Sea-going Spar Deck Steam Vessels (in Salt Water).

Coefficient of Fineness.	Height of Freeboard Amidships (Winter). Measured from Top of Spar Deck at Side. Moulded Depth (to Main Deck) and Length.					
	′ ″ 13 0	′ ″ 13 6	′ ″ 14 0	′ ″ 14 6	′ ″ 15 0	′ ″ 15 6
	′ 240	′ 246	′ 252	′ 258	′ 264	′ 270
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
0.68	5 5	5 6	5 7	5 8	5 9	5 10
0.70	5 5½	5 6½	5 7½	5 8½	5 9½	5 10½
0.72	5 6	5 7	5 8	5 9	5 10	5 11
0.74	5 6½	5 7½	5 8½	5 9½	5 10½	5 11½
0.76	5 7	5 8	5 9	5 10	5 11	6 0
0.78	5 7½	5 8½	5 9½	5 10½	5 11½	6 0½
0 80	5 8	5 9	5 10	5 11	6 0	6 1
0.82	5 8½	5 9½	5 10½	5 11½	6 0½	6 1½
rection in ins. a change of in the length.	0.9	0.9	0.9	0.9	0.9	0.9
luction in ins. summer yages.	2	2	2	2	2½	2½

Table B. — (*Continued.*)

Cargo-carrying Spar Deck Vessels.

Table of Freeboard to Spar Deck for First-class Sea-going Spar Deck Steam Vessels (in Salt Water).

Coefficient of Fineness.	Height of Freeboard Amidships (Winter). Measured from Top of Spar Deck at Side. Moulded Depth (to Main Deck) and Length.					
	16′ 0″	16′ 6″	17′ 0″	17′ 6″	18′ 0″	18′ 6″
	276′	282′	288′	294′	300′	306′
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
0.68	5 11	6 0	6 1½	6 2½	6 4	6 5½
0.70	5 11½	6 0½	6 2	6 3½	6 5	6 6½
0.72	6 0	6 1	6 2½	6 4	6 5½	6 7
0.74	6 0½	6 1½	6 3	6 4½	6 6	6 7½
0.76	6 1	6 2	6 3½	6 5	6 6½	6 8
0.78	6 1½	6 2½	6 4	6 5½	6 7	6 8½
0.80	6 2	6 3	6 4½	6 6	6 7½	6 9
0.82	6 2½	6 3½	6 5	6 6½	6 8	6 9½
Correction in ins. for a change of 10′ in the length.	1.0	1.0	1.0	1.0	1.0	1.0
Deduction in ins. for summer voyages.	2½	2½	3	3	3	3

Table B. — (*Continued.*)

Cargo-carrying Spar Deck Vessels.

Table of Freeboard to Spar Deck for First-class Sea-going Spar Deck Steam Vessels (in Salt Water).

Coefficient of Fineness.	Height of Freeboard Amidships (Winter). Measured from Top of Spar Deck at Side.											
	Moulded Depth (to Main Deck) and Length.											
	′	″	′	″	′	″	′	″	′	″	′	″
	19	0	19	6	20	0	20	6	21	0	21	6
	′ 312		′ 318		′ 324		′ 330		′ 336		′ 342	
	′	″	′	″	′	″	′	″	′	″	′	″
0.68	6	7½	6	9	6	11	7	0½	7	2½	7	4½
0.70	6	8½	6	10	7	0	7	1½	7	3½	7	5½
0.72	6	9	6	10½	7	0½	7	2	7	4	7	6
0.74	6	9½	6	11	7	1	7	3	7	5	7	7
0.76	6	10	6	11½	7	1½	7	3½	7	5½	7	7½
0.78	6	10½	7	0	7	2	7	4	7	6	7	8
0.80	6	11	7	0½	7	2½	7	4½	7	6½	7	8½
0.82	6	11½	7	1	7	3	7	5	7	7	7	9
Correction in ins. for a change of 10′ in the length.	1.1		1.1		1.1		1.1		1.1		1.2	
Deduction in ins. for summer voyages.	3½		3½		3½		4		4		4	

Table B.—(*Continued.*)

Cargo-carrying Spar Deck Vessels.

Table of Freeboard to Spar Deck for First-class Sea-going Spar Deck Steam Vessels (in Salt Water).

Coefficient of Fineness.	Height of Freeboard Amidships (Winter). Measured from Top of Spar Deck at Side.					
	Moulded Depth (to Main Deck) and Length.					
	′ ″ 22 0	′ ″ 22 6	′ ″ 23 0	′ ″ 23 6	′ ″ 24 0	′ ″ 24 6
	′ 348	′ 354	′ 360	′ 366	′ 372	′ 378
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
0.68	7 7	7 9	7 11½	8 2	8 4½	8 7
0.70	7 8	7 10	8 0½	8 3	8 5½	8 8
0.72	7 8½	7 10½	8 1	8 3½	8 6	8 8½
0.74	7 9½	7 11½	8 2	8 4½	8 7	8 9½
0.76	7 10	8 0	8 2½	8 5	8 7½	8 10
0.78	7 10½	8 0½	8 3	8 5½	8 8	8 11
0.80	7 11	8 1	8 3½	8 6	8 8½	8 11½
0.82	7 11½	8 1½	8 4	8 7	8 9½	9 0½
Correction in ins. for a change of 10′ in the length.	1.2	1.2	1.2	1.2	1.3	1.3
Deduction in ins. for summer voyages.	4½	4½	4½	5	5	5

Table B. — (*Continued.*)

Cargo-carrying Spar Deck Vessels.

Table of Freeboard to Spar Deck for First-class Sea-going Spar Deck Steam Vessels (in Salt Water).

Coefficient of Fineness.	Height of Freeboard Amidships (Winter). Measured from Top of Spar Deck at Side.					
	Moulded Depth (Main Deck) and Length.					
	′ ″ 25 0	′ ″ 25 6	′ ″ 26 0	′ ″ 26 6	′ ″ 27 0	′ ″ 27 6
	′ 384	′ 390	′ 396	′ 402	′ 408	′ 414
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
0.68	8 9½	9 0	9 2½	9 5½	9 8	9 11
0.70	8 10½	9 1	9 3½	9 6½	9 9	10 0
0.72	8 11	9 2	9 4½	9 7½	9 10	10 1
0.74	9 0	9 3	9 5½	9 8½	9 11	10 2
0.76	9 0½	9 3½	9 6	9 9	10 0	10 3
0.78	9 1½	9 4½	9 7	9 10	10 1	10 4
0.80	9 2	9 5	9 7½	9 10½	10 1½	10 4½
0.82	9 3	9 6	9 8½	9 11½	10 2½	10 5½
Correction in ins. for a change of 10′ in the length.	1.3	1.3	1.3	1.4	1.4	1.4
Deduction in ins. for summer voyages.	5½	5½	5½	5½	6	6

Table B.—(*Continued.*)

Cargo-carrying Spar Deck Vessels.

Table of Freeboard to Spar Deck for First-class Sea-going Spar Deck Steam Vessels (in Salt Water).

Coefficient of Fineness.	Height of Freeboard Amidships (Winter). Measured from Top of Spar Deck at Side. Moulded Depth (to Main Deck) and Length.				
	′ ″ 28 0	′ ″ 28 6	′ ″ 29 0	′ ″ 29 6	′ ″ 30 0
	′ 420	′ 426	′ 432	′ 438	′ 444
	′ ″	′ ″	′ ″	′ ″	′ ″
0.68	10 2	10 5	10 8½	10 11½	11 3
0.70	10 3	10 6	10 9½	11 0½	11 4
0.72	10 4	10 7	10 10½	11 1½	11 5
0.74	10 5	10 8	10 11½	11 2½	11 6
0.76	10 6	10 9	11 0½	11 3½	11 7
0.78	10 7	10 10	11 1½	11 4½	11 8
0.80	10 7½	10 10½	11 2	11 5½	11 9
0.82	10 8½	10 11½	11 3	11 6½	11 10
Correction in ins. for a change of 10′ in the length.	1.4	1.5	1.5	1.5	1.5
Deduction in ins. for summer voyages.	6	6	6½	6½	6½

Table C.

Cargo-carrying Awning Deck Vessels.

Table of Freeboard for First-class Sea-going Awning Deck Steam Vessels (in Salt Water).

Coefficient of Fineness.	Height of Freeboard Amidships (Winter). Measured from Top of Main Deck at Side. Moulded Depth (to Main Deck) and Length.											
	′	″	′	″	′	″	′	″	′	″	′	″
	8	0	8	6	9	0	9	6	10	0	10	6
	96′		102′		108′		114′		120′		126′	
	′	″	′	″	′	″	′	″	′	″	′	″
0.66	0	1	0	1	0	1½	0	1½	0	2	0	2
0.68	0	1	0	1	0	1½	0	1½	0	2	0	2
0.70	0	1	0	1	0	1½	0	1½	0	2	0	2
0.72	0	1½	0	1½	0	2	0	2	0	2½	0	2½
0.74	0	1½	0	1½	0	2	0	2	0	2½	0	2½
0.76	0	1½	0	1½	0	2	0	2½	0	2½	0	3
0.78	0	1½	0	1½	0	2	0	2½	0	2½	0	3
0.80	0	2	0	2	0	2½	0	3	0	3	0	3½
Correction in ins. for a change of 10′ in the length.	0.4		0.4		0.4		0.4		0.4		0.5	
Deduction in ins. for summer voyages.	2		2		2		2		2		2	

Table C. — (*Continued.*)

Cargo-carrying Awning Deck Vessels.

Table of Freeboard for First-class Sea-going Awning Deck Steam Vessels (in Salt Water).

Coefficient of Fineness.	Height of Freeboard Amidships (Winter). Measured from Top of Main Deck at Side.					
	Moulded Depth (to Main Deck) and Length.					
	′ ″ 11 0	′ ″ 11 6	′ ″ 12 0	′ ″ 12 6	′ ″ 13 0	′ ″ 13 6
	′ 132	′ 138	′ 144	′ 150	′ 156	′ 162
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
0.66	0 2½	0 2½	0 3	0 3½	0 4	0 4½
0.68	0 2½	0 2½	0 3	0 3½	0 4	0 4½
0.70	0 2½	0 2½	0 3	0 3½	0 4	0 4½
0.72	0 3	0 3	0 3½	0 4	0 4½	0 5
0.74	0 3	0 3	0 3½	0 4	0 4½	0 5
0.76	0 3	0 3½	0 4	0 4½	0 5	0 5½
0.78	0 3	0 3½	0 4	0 4½	0 5	0 5½
0.80	0 3½	0 4	0 4½	0 5	0 5½	0 6
Correction in ins. for a change of 10′ in the length.	0.5	0.5	0.5	0.5	0.5	0.5
Deduction in ins. for summer voyages.	2	2	2	2	2	2

Table C. — *(Continued.)*

Cargo-carrying Awning Deck Vessels.

Table of Freeboard for First-class Sea-going Awning Deck Steam Vessels (in Salt Water).

Coefficient of Fineness.	Height of Freeboard Amidships (Winter). Measured from Top of Main Deck at Side.					
	Moulded Depth (to Main Deck) and Length.					
	′ ″ 14 0	′ ″ 14 6	′ ″ 15 0	′ ″ 15 6	′ ″ 16 0	′ ″ 16 6
	′ 168	′ 174	′ 180	′ 186	′ 192	′ 198
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
0.66	0 5	0 5½	0 6	0 6½	0 7	0 7½
0.68	0 5	0 5½	0 6	0 6½	0 7	0 7½
0.70	0 5½	0 6	0 6½	0 7	0 7½	0 8
0.72	0 5½	0 6	0 6½	0 7	0 8	0 8½
0.74	0 6	0 6½	0 7	0 7½	0 8	0 8½
0.76	0 6	0 6½	0 7	0 7½	0 8½	0 9
0.78	0 6½	0 7	0 7½	0 8	0 9	0 9½
0.80	0 6½	0 7	0 7½	0 8	0 9	0 9½
Correction in ins. for a change of 10′ in the length.	0.5	0.5	0.5	0.5	0.5	0.5
Deduction in ins. for summer voyages.	2	2	2	2	2	2½

Table C. — (*Continued.*)

Cargo-carrying Awning Deck Vessels.

Table of Freeboard for First-class Sea-going Awning Deck Steam Vessels (in Salt Water).

Coefficient of Fineness.	Height of Freeboard Amidships (Winter). Measured from Top of Main Deck at Side. Moulded Depth (to Main Deck) and Length.					
	′ ″ 17 0	′ ″ 17 6	′ ″ 18 0	′ ″ 18 6	′ ″ 19 0	′ ″ 19 6
	′ 204	′ 210	′ 216	′ 222	′ 228	′ 234
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
0.66	0 8½	0 9	0 10	0 11	1 0	1 1½
0.68	0 8½	0 9	0 10	0 11	1 0	1 1½
0 70	0 9	0 9½	0 10½	0 11½	1 0½	1 2
0 72	0 9½	0 10	0 11	1 0	1 1	1 2½
0.74	0 9½	0 10	0 11	1 0	1 1	1 2½
0.76	0 10	0 10½	0 11½	1 0½	1 1½	1 3
0.78	0 10½	0 11	1 0	1 1	1 2	1 3½
0 80	0 10½	0 11	1 0	1 1	1 2	1 3½
Correction in ins. for a change of 10′ in the length.	0 5	0 5	0.5	0.6	0.6	0.6
Deduction in ins. for summer voyages.	2½	2½	2½	3	3	3

Table C. — (*Continued.*)

Cargo-carrying Awning Deck Vessels.

Table of Freeboard for First-class Sea-going Awning Deck Steam Vessels (in Salt Water).

Coefficient of Fineness.	Height of Freeboard Amidships (Winter). Measured from Top of Main Deck at Side.					
	Moulded Depth (to Main Deck) and Length.					
	′ ″ 20 0	′ ″ 20 6	′ ″ 21 0	′ ″ 21 6	′ ″ 22 0	′ ″ 22 6
	′ 240	′ 246	′ 252	′ 258	′ 264	′ 270
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
0.66	1 2½	1 4	1 5	1 6½	1 7½	1 8½
0.68	1 2½	1 4	1 5	1 6½	1 7½	1 9
0.70	1 3	1 4½	1 5½	1 7	1 8	1 9½
0.72	1 3½	1 5	1 6	1 7½	1 8½	1 10
0.74	1 3½	1 5	1 6	1 7½	1 8½	1 10
0.76	1 4	1 5½	1 6½	1 8	1 9	1 10½
0.78	1 4½	1 6	1 7	1 8½	1 9	1 11
0.80	1 5	1 6½	1 7½	1 9	1 10	1 11½
Correction in ins. for a change of 10′ in the length.	0.6	0.6	0.6	0.6	0.6	0.6
Deduction in ins. for summer voyages.	3½	3½	3½	3½	4	4

Table C.—(*Continued.*)

Cargo-carrying Awning Deck Vessels.

Table of Freeboard for First-class Sea-going Awning Deck Steam Vessels (in Salt Water).

Coefficient of Fineness.	Height of Freeboard Amidships (Winter). Measured from Top of Main Deck at Side. Moulded Depth (to Main Deck) and Length.					
	′ ″ 23 0	′ ″ 23 6	′ ″ 24 0	′ ″ 24 6	′ ″ 25 0	′ ″ 25 6
	′ 276	′ 282	′ 288	′ 294	′ 300	′ 306
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
0.66	1 10	1 11½	2 1	2 3	2 4½	2 6½
0.68	1 10½	2 0	2 1½	2 3½	2 5	2 7
0.70	1 11	2 0½	2 2	2 4	2 5½	2 7½
0.72	1 11½	2 1	2 2½	2 4½	2 6	2 8
0.74	1 11½	2 1	2 3	2 5	2 6½	2 8½
0.76	2 0	2 1½	2 3½	2 5½	2 7	2 9
0.78	2 0½	2 2	2 4	2 6	2 7½	2 9½
0.80	2 1	2 2½	2 4½	2 6½	2 8	2 10
Correction in ins. for a change of 10′ in the length.	0.6	0.6	0.6	0.7	0.7	0.7
Deduction in ins. for summer voyages.	4	4½	4½	4½	5	5

Table C.—(*Continued.*)

Cargo-carrying Awning Deck Vessels.

Table of Freeboard for First-class Sea-going Awning Deck Steam Vessels (in Salt Water).

Coefficient of Fineness.	Height of Freeboard Amidships (Winter). Measured from Top of Main Deck at Side. Moulded Depth (to Main Deck) and Length.					
	′ ″ 26 0	′ ″ 26 6	′ ″ 27 0	′ ″ 27 6	′ ″ 28 0	′ ″ 28 6
	′ 312	′ 318	′ 324	′ 330	′ 336	′ 342
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
0.66	2 8	2 10	3 0½	3 2½	3 4½	3 6½
0.68	2 8½	2 10½	3 1	3 3	3 5	3 7
0.70	2 9	2 11	3 1½	3 3½	3 5½	3 7½
0.72	2 9½	2 11½	3 2	3 4	3 6	3 8
0.74	2 10	3 0	3 2½	3 4½	3 6½	3 8½
0.76	2 11	3 1	3 3½	3 5½	3 7½	3 9½
0.78	2 11½	3 1½	3 4	3 6	3 8	3 10
0.80	3 0	3 2	3 4½	3 8½	3 6½	3 10½
Correction in ins. for a change of 10′ in the length.	0.7	0.7	0.7	0.7	0.7	0.7
Deduction in ins. for summer voyages.	5	5½	5½	5½	5½	6

Table C. — (*Continued.*)

Cargo-carrying Awning Deck Vessels.

Table of Freeboard for First-class Sea-going Awning Deck Steam Vessels (in Salt Water).

Coefficient of Fineness.	Height of Freeboard Amidships (Winter). Measured from Top of Main Deck at Side.					
	Moulded Depth (to Main Deck) and Length.					
	′ ″ 29 0	′ ″ 29 6	′ ″ 30 0	′ ″ 30 6	′ ″ 31 0	′ ″ 31 6
	′ 348	′ 354	′ 360	′ 366	′ 372	′ 378
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
0.66	3 8½	3 10½	4 0½	4 3	4 5½	4 8
0.68	3 9	3 11	4 1½	4 4	4 6½	4 9
0.70	3 9½	3 11½	4 2	4 4½	4 7	4 9½
0.72	3 10	4 0½	4 3	4 5½	4 8	4 10½
0.74	3 10½	4 1	4 3½	4 6	4 8½	4 11
0.76	3 11½	4 2	4 4½	4 7	4 9½	5 0
0.78	4 0	4 2½	4 5	4 7½	4 10	5 0½
0.80	4 0½	4 3	4 5½	4 8	4 10½	5 1
Correction in ins. for a change of 10′ in the length.	0.7	0.8	0.8	0.8	0.8	0.8
Deduction in ins. for summer voyages.	6	6	6	6	6	6½

Table C.—(*Continued.*)

Cargo-carrying Awning Deck Vessels.

Table of Freeboard for First-class Sea-going Awning Deck Steam Vessels (in Salt Water).

Coefficient of Fineness.	Height of Freeboard Amidships (Winter). Measured from Top of Main Deck at Side. Moulded Depth (to Main Deck) and Length.					For Steamers above 34′ Moulded Depth Deduct the Following Amount from the Freeboards Given in Table A to Obtain the Freeboards for Table C.
	32′ 0″	32′ 6″	33′ 0″	33′ 6″	34′ 0″	
	384′	390′	396′	402′	408′	
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
0.66	4 10½	5 1	5 3½	5 6	5 8	3 0
0.68	4 11½	5 2	5 4½	5 7	5 9	3 0
0.70	5 0	5 2½	5 5	5 7½	5 9½	3 1
0.72	5 1	5 3½	3 6	5 8½	5 10½	3 1
0.74	5 1½	5 4	5 6½	5 9	5 11	3 2
0.76	5 2½	5 5	5 7½	5 10	6 0	3 2
0.78	5 3	5 5½	5 8	5 10½	6 0½	3 3
0.80	5 3½	5 6	5 8½	5 11	6 1½	3 3
Correction in ins. for a change of 10′ in the length.	0 8	0 8	0 8	0 8	0 8	
Deduction in ins. for summer voyages.	6½	6½	6½	6½	6½	

Table D.

Sailing Vessels.

Table of Reserve Buoyancy and Freeboard for First-class Sea-going Iron and Steel Sailing Vessels and Composite and Wood Vessels of the Highest Class (in Salt Water).

Coefficient of Fineness.			Percentage Reserve Buoyancy (Iron Vessels).				
			21.7	21.9	22.1	22.3	22.5
			Corresponding Height of Freeboard Amidships. Measured from Top of Deck at Side.				
			Moulded Depth and Length.				
Wood.	Composite.	Iron.	5′ 6″	6′ 0″	6′ 6″	7′ 0″	7′ 6″
			55′	60′	65′	70′	75′
			′ ″	′ ″	′ ″	′ ″	′ ″
....	....	0.64	0 8½	0 9½	0 10½	0 11½	1 0½
....	0.64	0.66	0 8½	0 9½	0 10½	0 11½	1 0½
....	0.66	0.68	0 9	0 10	0 11	1 0	1 1
0.64	0.68	0.70	0 9	0 10	0 11	1 0	1 1
0.66	0.70	0.72	0 9½	0 10½	0 11½	1 0½	1 1½
0.68	0.72	0.74	0 9½	0 10½	0 11½	1 0½	1 1½
0.70	0.74	....	0 10	0 11	1 0	1 1	1 2
0.72	....	....	0 10	0 11	1 0	1 1	1 2
Correction in ins. for a change of 10′ in the length.			0.8	0.8	0.8	0.8	0.8

Table D. — (*Continued.*)
Sailing Vessels.

Table of Reserve Buoyancy and Freeboard for First-class Sea-going Iron and Steel Sailing Vessels and Composite and Wood Vessels of the Highest Class (in Salt Water).

Coefficient of Fineness.			Percentage Reserve Buoyancy (Iron Vessels).				
			22.7	22.9	23.1	23.3	23.5
			Corresponding Height of Freeboard Amidships. Measured from Top of Deck at Side.				
			Moulded Depth and Length.				
Wood.	Composite.	Iron.	′ ″ 8 0	′ ″ 8 6	′ ″ 9 0	′ ″ 9 6	′ ″ 10 0
			′ 80	′ 85	′ 90	′ 95	′ 100
			′ ″	′ ″	′ ″	′ ″	′ ″
....	....	0.64	1 1½	1 2½	1 3½	1 4½	1 5½
....	0.64	0.66	1 1½	1 2½	1 3½	1 4½	1 5½
....	0.66	0.68	1 2	1 3	1 4	1 5	1 6
0.64	0.68	0.70	1 2	1 3	1 4	1 5	1 6
0.66	0.70	0.72	1 2½	1 3½	1 4½	1 5½	1 6½
0.68	0.72	0.74	1 2½	1 3½	1 4½	1 5½	1 6½
0.70	0.74	....	1 3	1 4	1 5	1 6	1 7
0.72	....	....	1 3	1 4	1 5	1 6	1 7
Correction in ins. for a change of 10′ in the length.			0.8	0.9	0.9	0.9	0.9

Table D. — (*Continued.*)

Sailing Vessels.

Table of Reserve Buoyancy and Freeboard for First-class Sea-going Iron and Steel Sailing Vessels and Composite and Wood Vessels of the Highest Class (in Salt Water).

Coefficient of Fineness.			Percentage Reserve Buoyancy (Iron Vessels).				
			23.7	23.9	24.2	24.4	24.6
			Corresponding Height of Freeboard Amidships. Measured from Top of Deck at Side.				
			Moulded Depth and Length.				
Wood.	Composite.	Iron.	′ ″ 10 6	′ ″ 11 0	′ ″ 11 6	′ ″ 12 0	′ ″ 12 6
			′ 105	′ 110	′ 115	′ 120	′ 125
			′ ″	′ ″	′ ″	′ ″	′ ″
....	....	0.64	1 6½	1 7½	1 9	1 10½	1 11½
....	0.64	0.66	1 6½	1 7½	1 9	1 10½	2 0
....	0.66	0.68	1 7	1 8	1 9½	1 11	2 0½
0.64	0.68	0.70	1 7	1 8½	1 10	1 11½	2 1
0.66	0.70	0.72	1 7½	1 9	1 10½	2 0	2 1½
0.68	0.72	0.74	1 7½	1 9	1 10½	2 0	2 1½
0.70	0.74	....	1 8	1 9½	1 11	2 0½	2 2
0.72	....	....	1 8½	1 10	1 11½	2 1	2 2½
Correction in ins. for a change of 10′ in the length.			0.9	0.9	1.0	1.0	1.0

Table D. — (*Continued.*)

Sailing Vessels.

Table of Reserve Buoyancy and Freeboard for First-class Sea-going Iron and Steel Sailing Vessels and Composite and Wood Vessels of the Highest Class (in Salt Water).

Coefficient of Fineness.			Percentage Reserve Buoyancy (Iron Vessels).				
			24.9	25.1	25.3	25.5	25.7
			Corresponding Height of Freeboard Amidships. Measured from Top of Deck at Side.				
			Moulded Depth and Length.				
Wood.	Composite.	Iron.	′ ″ 13 0	′ ″ 13 6	′ ″ 14 0	′ ″ 14 6	′ ″ 15 0
			′ 130	′ 135	′ 140	′ 145	′ 150
			′ ″	′ ″	′ ″	′ ″	′ ″
....	....	0.64	2 1	2 2½	2 3½	2 5	2 6½
....	0.64	0.66	2 1½	2 3	2 4	2 5½	2 7
....	0.66	0.68	2 2	2 3½	2 4½	2 6	2 7½
0.64	0.68	0.70	2 2½	2 4	2 5	2 6½	2 8
0.66	0.70	0.72	2 3	2 4½	2 5½	2 7	2 8½
0.68	0.72	0.74	2 3	2 4½	2 6	2 7	2 9
0.70	0.74	....	2 3½	2 5	2 6½	2 8	2 9½
0.72	....	....	2 4	2 5½	2 7	2 8½	2 10
Correction in ins. for a change of 10′ in the length.			1.0	1.0	1.0	1.1	1.1

Table D. — (*Continued.*)

Sailing Vessels.

Table of Reserve Buoyancy and Freeboard for First-class Sea-going Iron and Steel Sailing Vessels and Composite and Wood Vessels of the Highest Class (in Salt Water).

Coefficient of Fineness.			Percentage Reserve Buoyancy (Iron Vessels).				
			26 0	26 2	26.4	26 6	26 8
			Corresponding Height of Freeboard Amidships. Measured from Top of Deck at Side.				
			Moulded Depth and Length.				
Wood.	Com-posite.	Iron.	′ ″ 15 6	′ ″ 16 0	′ ″ 16 6	′ ″ 17 0	′ ″ 17 6
			′ 155	′ 160	′ 165	′ 170	′ 175
			′ ″	′ ″	′ ″	′ ″	′ ″
.		0 64	2 8	2 9½	2 11	3 0½	3 2
	0 64	0 66	2 8½	2 10	2 11½	3 1	3 2½
. . .	0 66	0 68	2 9	2 10½	3 0	3 1½	3 3
0 64	0 68	0 70	2 9½	2 11	3 0½	3 2	3 3½
0 66	0 70	0 72	2 10	2 11	3 1	3 2½	3 4
0 68	0 72	0 74	2 10½	3 0	3 1½	3 3	3 4½
0 70	0 74	. . .	2 11	3 0½	3 2	3 3½	3 5
0 72		.	2 11½	3 1	3 2½	3 4	3 5½
Correction in ins. for a change of 10′ in the length			1 1	1 1	1 1	1 1	1.1

Table D. — (*Continued.*)

Sailing Vessels.

Table of Reserve Buoyancy and Freeboard for First-class Sea-going Iron and Steel Sailing Vessels and Composite and Wood Vessels of the Highest Class (in Salt Water).

Coefficient of Fineness.			Percentage Reserve Buoyancy (Iron Vessels).				
			27.1	27.3	27.4	27.5	27.6
			Corresponding Height of Freeboard Amidships. Measured from Top of Deck at Side.				
			Moulded Depth and Length.				
Wood.	Composite.	Iron.	18′ 0″	18′ 6″	19′ 0″	19′ 6″	20′ 0″
			180′	185′	190′	195′	200′
			′ ″	′ ″	′ ″	′ ″	′ ″
.		0.64	3 3½	3 5	3 6½	3 8	3 9½
. .	0.64	0.66	3 4	3 5½	3 7	3 8½	3 10
. .	0.66	0.68	3 4½	3 6	3 7½	3 9	3 10½
0.64	0.68	0.70	3 5	3 6½	3 8	3 9½	3 11
0.66	0.70	0.72	3 5½	3 7½	3 9	3 10½	4 0
0.68	0.72	0.74	3 6	3 8	3 9½	3 11	4 0½
0.70	0.74	....	3 6½	3 8½	3 10	3 11½	4 1
0.72	....	.	3 7	3 9	3 10½	4 0	4 1½
Correction in ins. for a change of 10′ in the length.			1.1	1.1	1.2	1.2	1.2

Table D. — (*Continued.*)

Sailing Vessels.

Table of Reserve Buoyancy and Freeboard for First-class Sea-going Iron and Steel Sailing Vessels and Composite and Wood Vessels of the Highest Class (in Salt Water).

Coefficient of Fineness.			Percentage Reserve Buoyancy (Iron Vessels).				
			27.7	27.9	28.0	28.2	28.3
			Corresponding Height of Freeboard Amidships. Measured from Top of Deck at Side.				
			Moulded Depth and Length.				
Wood.	Composite.	Iron.	′ ″ 20 6	′ ″ 21 0	′ ″ 21 6	′ ″ 22 0	′ ″ 22 6
			′ 205	′ 210	′ 215	′ 220	′ 225
			′ ″	′ ″	′ ″	′ ″	′ ″
....	....	0.64	3 11	4 0½	4 2	4 3½	4 5
....	0.64	0.66	3 11½	4 1	4 3	4 4½	4 6
....	0.66	0.68	4 0	4 1½	4 3½	4 5	4 6½
0.64	0.68	0.70	4 0½	4 2	4 4	4 5½	4 7
0.66	0.70	0.72	4 1½	4 3	4 5	4 6½	4 8
0.68	0.72	0.74	4 2	4 3½	4 5½	4 7	4 8½
0.70	0.74	....	4 2½	4 4½	4 6	4 8	4 9½
0.72	....	....	4 3	4 5	4 7	4 8½	4 10
Correction in ins. for a change of 10′ in the length.			1.2	1.2	1.2	1.2	1.2

Table D. — (*Continued.*)

Sailing Vessels.

Table of Reserve Buoyancy and Freeboard for First-class Sea-going Iron and Steel Sailing Vessels and Composite and Wood Vessels of the Highest Class (in Salt Water).

Coefficient of Fineness.			Percentage Reserve Buoyancy (Iron Vessels).				
			28 5	28.6	28 8	28.9	29.1
			Corresponding Height of Freeboard Amidships. Measured from Top of Deck at Side.				
Wood.	Composite.	Iron.	Moulded Depth and Length.				
			′ ″ 23 0	′ ″ 23 6	′ ″ 24 0	′ ″ 24 6	′ ″ 25 0
			′ 230	′ 235	′ 240	′ 245	′ 250
			′ ″	′ ″	′ ″	′ ″	′ ″
....	..	0 64	4 6½	4 8	4 10	4 11½	5 1½
...	0 64	0 66	4 7½	4 9	4 10½	5 0	5 2
....	0 66	0 68	4 8	4 9½	4 11½	5 1	5 3
0 64	0 68	0 70	4 8½	4 10	5 0	5 1½	5 3½
0 66	0 70	0 72	4 9½	4 11	5 1	5 2½	5 4½
0.68	0 72	0 74	4 10	4 11½	5 1½	5 3	5 5
0 70	0 74	....	4 11	5 0½	5 2½	5 4	5 6
0 72	....	....	5 0	5 1½	5 3½	5 5	5 7
Correction in ins. for a change of 10′ in the length.			1 3	1 3	1.3	1 3	1.3

Table D. — (*Continued.*)

Sailing Vessels.

Table of Reserve Buoyancy and Freeboard for First-class Sea-going Iron and Steel Sailing Vessels and Composite and Wood Vessels of the Highest Class (in Salt Water).

Coefficient of Fineness.			Percentage Reserve Buoyancy (Iron Vessels).			
			29.2	29.4	29.5	29.7
			Corresponding Height of Freeboard Amidships. Measured from Top of Deck at Side.			
			Moulded Depth and Length.			
Wood.	Com-posite.	Iron.	′ ″ 25 6	′ ″ 26 0	′ ″ 26 6	′ ″ 27 0
			′ 255	′ 260	′ 265	′ 270
			′ ″	′ ″	′ ″	′ ″
....	....	0.64	5 3	5 5	5 6½	5 8½
....	0.64	0.66	5 3½	5 5½	5 7½	5 9½
....	0.66	0.68	5 4½	5 6½	5 8½	5 10½
0.64	0.68	0.70	5 5	5 7	5 9	5 11
0.66	0.70	0.72	5 6	5 8	5 10	6 0
0.68	0.72	0.74	5 6½	5 8½	5 10½	6 0½
0.70	0.74	....	5 7½	5 9½	5 11½	6 1½
0.72	....	....	5 8½	5 10½	6 0½	6 2½
Correction in ins. for a change of 10′ in the length.			1.3	1.3	1.3	1.4

Table D. — *(Continued.)*

Sailing Vessels.

Table of Reserve Buoyancy and Freeboard for First-class Sea-going Iron and Steel Sailing Vessels (in Salt Water).

Coefficient of Fineness.	Percentage Reserve Buoyancy.			
	29.8	30.0	30.2	30.4
	Corresponding Height of Freeboard Amidships. Measured from Top of Deck at Side.			
Iron.	Moulded Depth and Length.			
	′ ″ 27 6	′ ″ 28 0	′ ″ 28 6	′ ″ 29 0
	′ 275	′ 280	′ 285	′ 290
	′ ″	′ ″	′ ″	′ ″
0.64	5 10½	6 0½	6 2	6 4
0.66	5 11½	6 1½	6 3	6 5
0.68	6 0½	6 2	6 4	6 6
0.70	6 1	6 3	6 5	6 7
0.72	6 2½	6 4½	6 6	6 8
0.74	6 3½	6 5½	6 7	6 9
0.76				
Correction in ins. for a change of 10′ in the length.	1.4	1.4	1.4	1.4

Table D. — (*Continued.*)

Sailing Vessels.

Table of Reserve Buoyancy and Freeboard for First-class Sea-going Iron and Steel Sailing Vessels (in Salt Water).

Coefficient of Fineness.	Percentage Reserve Buoyancy.							
	30.6		30.8		31.1		31.4	
	Corresponding Height of Freeboard Amidships. Measured from Top of Deck at Side.							
	Moulded Depth and Length.							
Iron.	′	″	′	″	′	″	′	″
	29	6	30	0	30	6	31	0
	′ 295		′ 300		′ 305		′ 310	
	′	″	′	″	′	″	′	″
0.64	6	6	6	8	6	10	7	0
0.66	6	7	6	9	6	11	7	1
0.68	6	8	6	10	7	0	7	2
0.70	6	9	6	11	7	1	7	3
0.72	6	9½	6	11½	7	1½	7	3½
0.74	6	10	7	0	7	2	7	4
0.76	6	11	7	1	7	3	7	5
Correction in ins. for a change of 10′ in the length.	1.4		1.5		1.5		1.5	

CHAPTER V.

KIRK'S ANALYSIS.

(*Trans. Inst. of Nav. Arch.*)

The following was the method adopted, and here I may premise that for ordinary purposes I assumed that the length of entrance and run were equal—in fact I contented myself by finding the mean of the lengths and angles of entrance and run—but the method is equally applicable to finding them separately when greater accuracy is required.

I shall now give the process for finding the mean length and angle of entrance and run.

Construct a block ship having the same displacement, mean draught, and area of midship section as the ship under consideration, but with rectangular sections, parallel middle body (if necessary) and straight-sided wedge-shaped ends. Fig. 34 shows by the curved line *IBK* the midship section of the actual ship, and by the rectangle *CLME* the midship section of the block ship, both sections being equal in area and depth, having a common water line *IK*. The depth *AB* is the mean draught of the ship. Fig. 35 represents the block ship, and *ABDC* is the half-breadth plan, the sides being vertical, the transverse sections all rectangular, and the keel parallel to the water line. The sides *CD* and *EF* which form the middle body, are parallel to the keel (or to the centre line *AB*), and the half-breadth *GC* or *HD* is equal to *AC*, Fig. 34, the half-breadth of the equivalent rectangular midship section (which is in fact the midship section of the block ship), *EL* being also equal to *AB*. The angles *CAG* and *DBH* are equal, and while the length *AB* is equal to the length of the ship, the length *AG* or *HB* of equal wedges which form the ends is such that the area of the figure *ACDBFE* multiplied by the mean depth *AB*, is equal to the volume of the displacement of the actual ship.

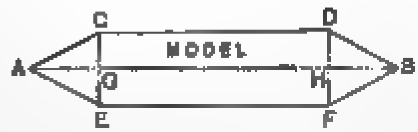
Complete the rectangle *COPE* as in the dotted lines. It is obvious that the rectangular solid *COPELQ* is equal in volume to that of the block ship, in fact to the volume of the displacement of the actual ship, and that the length

$$GB \text{ in feet} = \frac{\text{Displacement in cubic feet}}{\text{Area of midship section in square feet}},$$

and the mean length of entrance and run

$$AG = \text{length of ship} - \frac{\text{Displacement}}{\text{Midship area}},$$

Reference Number.	Description of Propeller.	Gross Register Tonnage.	Principal Dimensions.			Draught of Water on Trial.			Displacement.		Midship Section.	
			Length between Perpendiculars.	Breadth Moulded.	Depth Moulded.	Forward.	Aft.	Mean.	No. Tons.	Coefficient of Fineness.	Area.	Coefficient of Fineness.
			′ ″	′ ″	′ ″	′ ″	′ ″	′ ″			Sq.′	
1	S.S.	2,811	342 0	38 0	29 11	18 6	20 2	19 4	4,500	.658	643	.92
2	S.S.	2,811	342 0	38 0	29 11	18 4	19 9	19 0½	4,415	.656	630	.916
3	S.S.	2,911	344 0	39 0	29 11	16 0	20 0	18 0	4,235	.647	604	.907
4	S.S.	2,965	348 0	39 0	29 11	17 3	19 11	18 7	4,472	.653	626	.91
5	S.S.	974	230 0	32 0	19 0	7 0	13 0	10 0	1,227	.625	286	.89
6	S.S.	979	230 0	32 0	19 0	14 9	14 11	14 10	2,034	.683	423	.934
7	S.S	1,158	240 0	32 0	19 11	11 7	13 8	12 7½	1,093	.647	344	.902
8	S.S	2,014	285 0	36 0	26 6	13 7	15 10	14 8½	2,710	.685	454	.936
9	S.S.	534	190 0	25 6	15 0	11 7	12 11	12 3	1,115	.694	268	.904
10	T.S.	. . .	280 0	60 0	42 6	24 3	25 3	24 9	7,555	.663	1,287	.903
11	P.	. . .	203 8	26 6	16 0	10 6	10 6	10 6	885	.581	230	.87
12	T.S.	. . .	225 0	30 0	22 6	12 2	13 2	12 8	1,235	.533	285	.79
13	P.	. . .	98 0	13 0	8 3	4 9	5 3	5 0	133	.575	785	.87
14	S.S.	2,160	320 0	40 0	21 8 to main deck.	8 9	17 4½	13 0¾	2,336	.522	387	.791

I.H.P.	Speed in Knots.	Area of Immersed Surface Ex. Keel.								Immersed Surface of Ship Divided by Immersed Surface of Model.
			Length A.B.	Breadth C.E.	Draught Forward and Aft.	Length of Entrance A.G	Length of A.C.	Half Angles of Entrance C.A.G.	Area of Immersed Surface.	
		Sq. Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	° ′	Sq. Ft	
1,431	11.52	19,348	329.5	34.8	18.5	84.6	86 4	11 38	20,847	.928
642	9.18	19,140	329.5	34.6	18.2	84.2	85.9	11 37	20,605	.929
1,429	11.87	18,892	331.5	35.3	17.1	86.1	87.9	11 35	20,123	.938
2,106	12.94	19,506	335.5	35.4	17.7	85.6	87.3	11 42	20,854	.935
526	9.32	8,552	223 2	28.3	9.4	61.8	63.4	12 54	8,824	.969
806	10.33	10,850	221.2	29.8	14.2	54.9	56.9	15 11	11,468	.946
909	11.14	10,216	232.5	28.7	12.0	60.3	62.0	13 23	10,604	.963
1,195	11.57	13,947	277.7	32.4	14.0	68.8	70.7	13 15	14,650	.952
441	8.63	7,300	164.5	22 9	11.7	38.9	40.5	16 24	7,726	.945
. . .	. . .	24,021	283.0	54.1	23.8	77.5	82.1	19 14	25,026	.96
1,135	13.33	6,700	203.0	23.2	9.9	68.3	69.3	9 38	7,185	.932
1,460	13.66	8,440	220.8	23.7	12.0	69 1	70.1	9 44	8,942	.944
125	8.54	1,935	97.5	15.5	4.6	32 4	33.3	13 27	1,922	.993
2,252	13.89	13,750	312.0	31 5	12.3	100.8	102.0	8 53	14,387	.955

also, The breadth $CE = \dfrac{\text{Area midship section}}{\text{Mean draught (ex. keel)}}$,

and the tangent of the mean half-angle of entrance and run,

$$CAG = \frac{GC}{GA}.$$

Thus from the length, breadth, draught, area of midship section, and displacement, the mean length of entrance and run and the mean angle can be got. There are other methods of working this out, which will occur to any one, but the method given is perhaps the simplest.

In order to get the length and angle of entrance and run separately (instead of the mean as stated), it is necessary to have in addition, the displacement in two portions, one forward of the midship section, and one aft, the distance of the midship section from one end of the ship, and the mean draught of each of these portions; treating them, in fact, as two separate ships, one of which has no run and one no entrance.

In my earlier attempts I retained the actual breadth of the ship as the breadth of the block ship, and varied the depth, but I prefer the plan before given of using for the block ship the mean draught of the actual ship. In ships with extremely raking sterns or stern posts, I take the length at half depth when that can be got (or the mean length) as the length of the block ship. In single screw steamers, I take the length to the forward stern post.

The block ship will often be found of use in forming first or

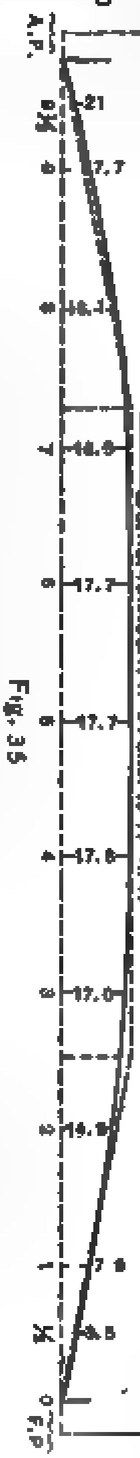


Fig. 35

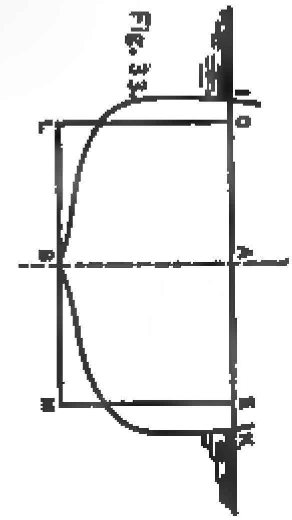


Fig. 33

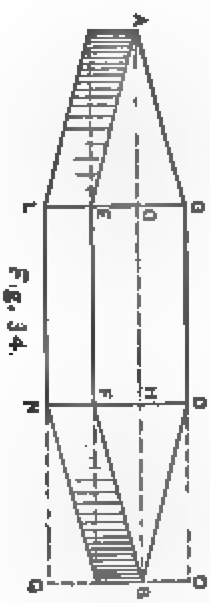


Fig. 34

approximate designs, and in this view it may be interesting to compare the wetted skin surface of actual ships with that of the equivalent block ships, this being an important element in speed calculations and otherwise.

In the foregoing table I have selected fourteen ships of very diverse types, giving their dimensions, block models, actual wetted surface (exclusive of that of keels or rudder), and wetted surface of block ship, and the ratio of one to the other.

From this it will be seen that in first approximations in comparing one ship with another we shall not commit a grievous error in using the surface of the block ship, and also that a very close approximation indeed may be made to the actual wetted surface by multiplying the surface of the block ship by one of the coefficients in the table, according to the type of the ship. In the second column *SS* means single screw, *TS* means twin screw, and *P* paddle. In No. 10 I ought to explain, that not only was the rudder of exceptional breadth, part of which, to make the comparison with the others more even, has been included, but there was a peculiar overhanging portion under water near the top of the stern post, by which the mean length taken for the block ship exceeds that of the actual ship between perpendiculars.

To show more clearly the relation of the block model to that of the actual ship, I have selected No. 4 in the table, as being a fair example of a merchant mail steamer of considerable speed, and in Fig. 36 I have given the curve of areas of transverse sections; and I have put it in this form that the ordinates are equal to the half areas of the corresponding transverse sections divided by the draught of water (less depth of keel) at the several sections. This is in fact the curve of form, or fineness of model.

Above this I have drawn the half-breadth plan of the block ship, the length, breadth, and area of this being of course equal to those of the curve, and the length and angle of entrance and run a mean of those of the actual curve of form.

Wetted Surface Formula.

$$\text{W.S.} = L \times \left(\frac{B}{2} + dr\right) \times c.$$

Where W.S. = wetted surface of hull proper in square feet, excluding bossing, rudder, bar keel, etc.

L = length on load water line.

B = extreme breadth.

dr = extreme draught in flat plate keel vessels, and draught corrected to flat plate keel conditions in bar keel vessels.

c = constant from the following table:

Ratio of $\frac{B}{dr}$ = 5.00		3.33	2.50	2.00	1.667
Block Co-efficient.	Values of "c"				
.40	1.120	1.130	1.153	1.180	1.200
.45	1.167	1.184	1.211	1.240	1.260
.50	1.215	1.238	1.270	1.300	1.320
.55	1.272	1.299	1.330	1.360	1.380
.60	1.330	1.360	1.390	1.420	1.440
.65	1.397	1.427	1.456	1.480	1.500
.70	1.465	1.494	1.522	1.541	1.560
.75	1.542	1.565	1.588	1.604	1.620
.80	1.620	1.637	1.655	1.668	1.680
.85	1.708	1.715	1.724	1.733	1.740

Wetted Surface (Taylor's Formula).

$$W.S. = c\sqrt{D \times L}.$$

where W.S. = wetted surface in square feet, excluding rudder, bossing, etc.:

D = displacement in tons of 35 cubic feet.

L = mean immersed length.

B = breadth extreme.

H = draught of water, extreme in flat plate keel vessels, and corrected to flat plate keel conditions in bar keel vessels.

c = constant found from the following table:

Ratio $\frac{B}{H}$.	Constant "c."	Ratio $\frac{B}{H}$.	Constant "c."
2.0	15.63	2.8	15.55
2.1	15.58	2.9	15.58
2.2	15.54	3.0	15.62
2.3	15.51	3.1	15.66
2.4	15.50	3.2	15.71
2.5	15.50	3.3	15.77
2.6	15.51	3.4	15.83
2.7	15.53	3.5	15.89

Note.—This formula becomes unreliable when the block coefficient is beyond the limits of .45 and .75, or when the ratio of $\frac{B}{H}$ is outside the limits given in the table.

CHAPTER VI.

LAUNCHING.*

The form of ways for ordinary merchant ships is of comparatively little importance ; but in special cases, such as armored war vessels or long, light river boats, if there is too little water on the way ends, the vessel is liable to tilt as soon as her C.G. gets over the way ends, and being as it were pivoted at this point, a great pressure is put upon the bottom of the vessel, causing undue local strains, which might possibly force in the bottom plating, frames, etc., in those vessels which are not so strongly constructed as ordinary merchant vessels, or the ways might collapse here and then

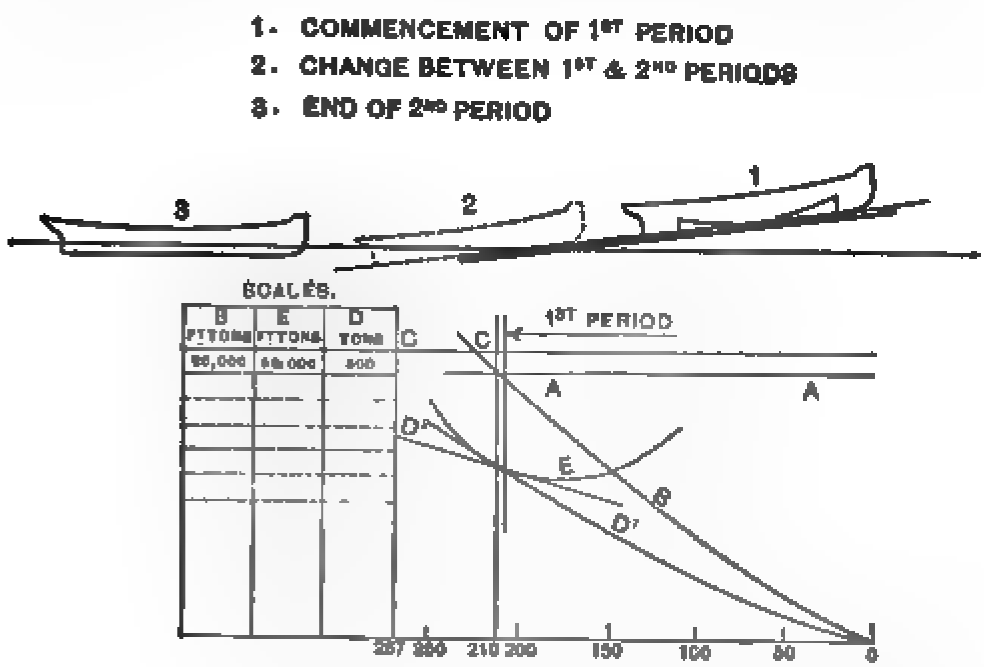


FIG. 36.

the vessel would be left to slide off the remaining distance on her keel. To guard against this danger, it is desirable to ascertain by calculations and diagrams if the form of the ways is such that the vessel may be launched without fear of tilting.

The time that a vessel takes to travel down the ways may be divided into two periods — the first lasts while she rests entirely

* Paper by H. G. Gannaway, Trans. E. Coast, Eng., and Shipb'd, 1887.

on the ways, and the second, when the stern is afloat and the fore end of the ship is bearing on the fore end of the sliding ways.

A base line is first drawn, the measurements along which represent distances travelled by the ship down the ways, the total length in this case being 267 feet. The line *AA* drawn parallel to the base represents the moment of the ship about the fore end of the sliding ways. In this example the ship's weight is 865 tons, which being multiplied by 97.2 feet, the distance of the C.G. of the ship from the fore end of the sliding ways, =84,121 foot-tons. The buoyancy moments about the same point are represented by curve *B*. The position of intersection of this curve with the line *AA* will indicate where the vessel will be when her stern commences to float aft. At this point the first period ends and the second commences, which in the example is when the vessel has travelled 208′ 6″ down the ways. Although this is the point where the moments of buoyancy and weight about the fore end of sliding ways become equal, the vessel's stern does not actually lift until she has moved a few feet beyond this, because an additional amount of displacement is required to overcome the vertical component of the ship's momentum.

Observations of the dip of the vessel's keel have proved that this additional displacement is so trifling that a complete investigation of its amount is unnecessary for ordinary purposes.

The displacement of the vessel throughout the first period is shown by curve D^1, and for the second period by curve D^2. During the second period, the after end of the vessel being afloat, and the fore end resting on the sliding ways, it is evident that the buoyancy moment about that point will remain the same as the weight moment all throughout this period. The displacement, of course, increases as the vessel moves down the ways, but the gradual lifting of the stern and lowering of the bows brings the C.B. further forward, and so reduces the leverage while the displacement is increasing, thus retaining practically a constant moment. The distance that the line *CC* is above the base, represents the weight of the ship, the weight on the fore end of the sliding ways being proportional to the distance between this line and curve of displacement D^2. This weight is 225 tons at the beginning of the period, and is reduced to 115 tons at the end. It is important, therefore, that the fore end of the cradle should be made sufficiently strong to carry the load which is thus put upon it. It will be seen then that it is desirable to reduce the duration of the second period as much as practicable, for, since the longer it is, the greater the weight will be on the fore end of the sliding ways, which in the case of heavy vessels renders them liable to come down to the ground and damage their fore ends.

In considering the subject of tipping, we take the moments

about the end of the standing ways, and as long as the buoyancy moment remains in excess of the weight moment about this point, there is no fear of the vessel tipping ; but if in any position the former moment falls short of the latter, it is evident that in order to restore equilibrium, the stern will drop, and thus increase the displacement until both moments are equal. Tipping, if occurring at all, must take place after the C.G. of the ship has passed the end of the standing ways, and before the commencement of the second period. In the example, the C.G. of the ship has passed

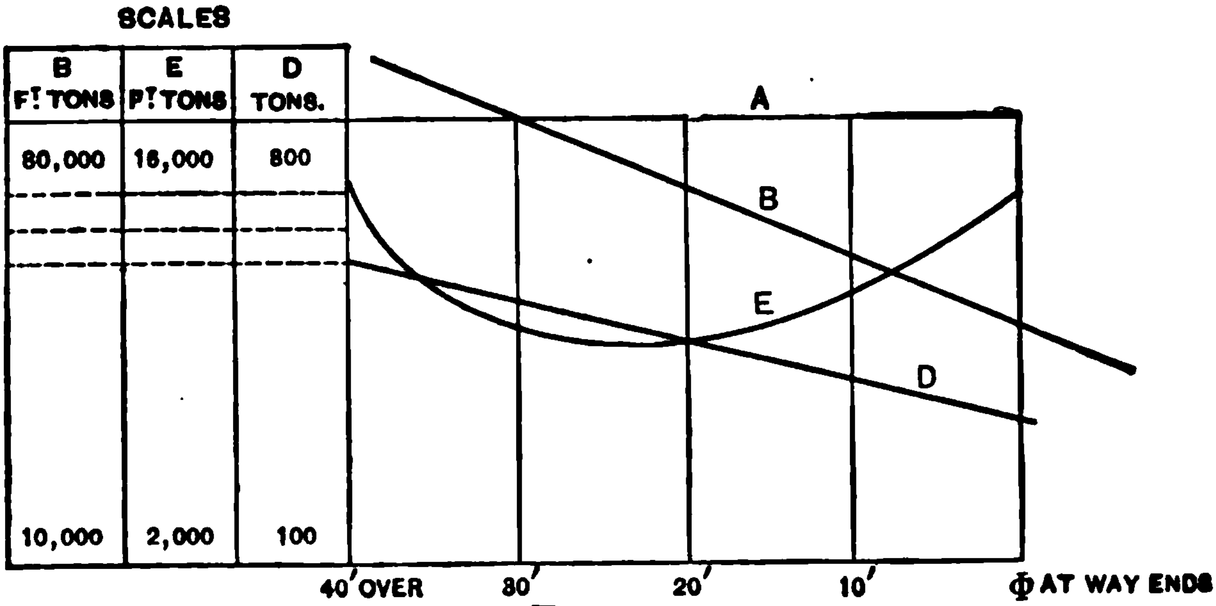


FIG. 37.

the way ends when she has moved 174 feet. From about that point to a little beyond the end of the first period, the buoyancy and weight moments about the end of the standing ways are calculated at several intervals, and at each interval the latter moment, being deducted from the former, gives the moments against tipping. These moments are shown by curve *E*. If this curve at any part were to run below the base line, it would show that the vessel will tilt. The point where this curve is nearest to the base line gives the position of the vessel when she has least longitudinal stability, which in this case is when the vessel has travelled down the ways 189 feet, the minimum margin against tipping being 9,700 foot-tons.

It is desirable that the margin be not too small for uncertain vessels ; where this was the case they actually did tilt slightly, which shows that a moderate margin is required in calculation to allow for the error introduced by treating, as it is convenient to do in practice, those moments statically instead of dynamically. In calculating the buoyancy moments no account is taken of the cradle, which would only alter the results slightly ; the variations being on the right side, may be safely ignored. Besides, the after

Table of

INDEX LETTER.	A	B	C	D
Description of Vessel and Moulded Dimensions in Feet.	T.S. Warship, 300′ × 58′ × 37′.	Screw Steamer, 380′ × 38′ × 28′.	Screw Steamer, 400′ × 42′ × 29½′.	Screw Steamer, 380′ × 42½′ × 29′
Declivity of keel per foot	$\frac{5}{16}''$	$\frac{5}{16}''$	$\frac{5}{16}''$	$\frac{5}{16}''$
Declivity of standing ways per foot	$\frac{5}{16}$ to $\frac{11}{16}$	$\frac{5}{16}$ to $\frac{11}{16}$	$\frac{5}{16}$ to $\frac{11}{16}$	$\frac{5}{16}$ to $\frac{11}{16}$
Camber of standing ways	2′ 8″	1′ 0″	1′ 2″	1′ 0″
Length of standing ways — Inner	345′	367′	395′	370′
Length of standing ways — Outer	288′			
Length of sliding ways — Inner	240′	284′	330′	305′
Length of sliding ways — Outer	165′			
Breadth of sliding ways — Inner	1′ 10″	1′ 9″	1′ 9″	1′ 9″
Breadth of sliding ways — Outer	1′ 8″			
Area of sliding ways in square feet	1,430	994	1,155	1,067
Total fall in length of standing ways	23′ 0″	18′ 9″	19′ 7″	18′ 6″
Water on way ends	8′ 7″	6′ 0″	4′ 4″	2′ 6″
Draught of ship forward	11′ 2″	11′ 6″	7′ 0″	8′ 0¾″
Draught of ship aft	16′ 6″	14′ 0″	10′ 10½″	10′ 5″
Draught of ship mean	13′ 10″	12′ 9″	9′ 0¾″	9′ 2⅝″
Displacement in tons	2,850	2,500	2,157	2,240
Mean pressure per square foot on sliding ways in tons	2.00	2.51	1.9	2.09
Length of first period	278.0	283	250.5	270.5
Length of second period	67	84	144.5	90.5
Ratio of length of 2d period to length of sliding ways	28%	30%	44%	30%
Weight on sliding ways at commencement of 2d period	520	550	640	630
Weight on sliding ways at end of second period (in tons)	250	290	300	380
Margin against tipping	10,500	33,250	80,000	35,300

Launching Data.

E	F	G	H	J	K	L	M
Screw Steamer, 330′ × 43½′ × 30½′.	Screw Steamer, 280′ × 38′ × 24′.	Screw Steamer, 270′ × 34′ × 19′.	Screw Steamer, 234′ × 33′ × 18′.	Sailing Ship, 220′ × 35′ × 22′.	Paddle Steamer, 190′ × 23′ × 9′.	Screw Steamer, 270′ × 35½′ × 19′.	Screw Steamer, 260′ × 35′ × 23′.
$\frac{9}{16}$″	$\frac{5}{16}$″	$\frac{5}{16}$″	$\frac{9}{16}$″	$\frac{5}{16}$″	$\frac{9}{16}$″	$\frac{3}{16}$″	$\frac{5}{16}$″
$\frac{5}{16}$ to $\frac{14}{16}$	$\frac{5}{16}$ to $\frac{16}{16}$	$\frac{5}{16}$ to $\frac{12}{16}$	$\frac{8}{16}$ to $\frac{14}{16}$	$\frac{8}{16}$ to $\frac{14}{16}$	$\frac{10}{16}$ to $\frac{14}{16}$	$\frac{5}{16}$ to $\frac{14}{16}$	$\frac{9}{16}$ to $\frac{13}{16}$
1′ 11″	1′ 10″	1′ 10″	1′ 0″	10″	8″	1′ 0″	6″
348′	302′	300′	267′	250′	105′	259′	276′
240′	200′	200′	180′	170′	150′	207′	190′
1′ 10″	1′ 8″	1′ 9″	1′ 9″	1′ 9″	1′ 3″	1′ 9″	1′ 9″
880	666	700	630	595	375	725	665
21′ 6″	18′ 10″	15′ 6″	15′ 4″	14′ 6″	12′ 0″	15′ 0″	16′ 0″
3′ 9″	3′ 10″	3′ 7″	2′ 8″	4′ 5″	2′ 9″	1′ 9″	2′ 0″
6′ 6½″	6′ 0″	5′ 7″	5′ 9″	8′ 7″	4′ 0″	6′ 11″	9′ 2″
9′ 5½″	8′ 2″	10′ 6″	9′ 0″	7′ 1″	3′ 10″	9′ 11″	12′ 0″
8′ 0″	7′ 1″	8′ 1½″	7′ 4½″	7′ 10″	3′ 11″	8′ 5″	10′ 7″
1,660	1,100	1,000	865	700	215	1,015	1,750
1.89	1.65	1.40	1.37	1.16	.57	1.4	2.63
237.5	202	249	208.5	190	122	212	. . .
110.5	100	51	58.5	60	73	47	. . .
46%	50%	25½%	32½%	35%	40%	23%	. . .
560	400	215	225	225	75	235	. . .
255	125	110	115	115	25	170	. . .
53,500	39,000	5,400	9,700	12,300	5,500	. . .	. . .

end of the sliding ways often rises to the surface shortly after the vessel has entered the water. In the diagram a complete set of curves has been given to fully illustrate the matter, but for practical purposes only that part of the diagram where the vessel is represented to be moving from the position where the C.G. is at the way ends, to the end of the second period, is required.

As the minimum moment against tipping is a very important thing, it will be useful to know what variation will be made in its amount by any alteration to the length and form of the standing ways of this vessel:

Lengthening the standing ways 10 feet increases the moment from 9,700 to 13,700 foot-tons.

Shortening the ways 10 feet decreases the moment to 5,300 foot-tons.

Increasing the camber from 12 inches to 18 inches increases the moment to 14,500 foot-tons.

Decreasing the camber to 6 inches decreases the moment to 4,000 foot-tons.

If with a certain declivity of ways for the launching of a vessel, it is found, by calculation, she will tilt, the standing ways must be extended further out into the water, or, if this cannot be done conveniently, their outer ends must be lowered, or ballast put into the fore end of the vessel. The first two increase the buoyancy moment about the end of the standing ways, and the third decreases the weight moment about the same point.

$$\text{Pressure on dog shores} = \frac{W \sin \delta - fW \cos \delta}{\cos \beta}.$$

W = weight of vessel.
δ = mean angle of declivity of ways under vessel.
β = angle between ways and dog shores.
f = coefficient of friction (between 1.0 and .7).

The ratio of second period to length of sliding ways cannot be got lower than about 25 per cent without danger of tipping.

RUDDERS.

In determining the most suitable area of rudder it is usual to take the same as a percentage of the immersed longitudinal plane of the ship, which percentage will vary with the degree of fineness of the vessel.

Percentage for Rudder Area in Various Types.

Type of Vessel.	Per Cent of Immersed Longitudinal Plane.
Fast ocean liners	1.25
Freighters	1.50
Yachts	1.10
Paddle steamers	2.0

Having fixed upon the area, the diameter of stock may be calculated by various formulæ, some of them, unfortunately, of a very approximate character, and on this account, where high speed will be attained, it is advisable to carefully calculate the required diameter irrespective of the result obtained by the classification societies' formulæ. For this purpose it is necessary to know, (1) the hard over angle of rudder, (2) centre of pressure on rudder blade, (3) maximum pressure exerted at hard over with ship at full speed. The angle of helm being usually 35°, the pressure on blade at this angle at full speed may be found from the formula, —P representing the pressure in lbs.

$$P = AV^2 \times \sin a \times p.$$

It should be stated that $V =$ speed of vessel in knots per hour plus 20 per cent to allow for the slip; $A =$ area of rudder in square feet, including emerged surface; and $p =$ pressure in lbs. per sq. foot at 1 knot, $= 3.19$ lbs. per sq. foot.

Before, however, the twisting moment on the stock can be solved, the centre of pressure must be located. This centre being $\frac{1}{3}$ the breadth from the leading edge with the helm amidships, does not arrive at the centre of gravity of rudder until 90° is reached, and as 35° is the usual angle, it will be sufficiently close to take .37 of the breadth of the rectangle equalling the rudder area:

$$\text{Centre of pressure from centre of stock} = l = \frac{A}{dr}.37.$$

The twisting moment T would then be

$$T = A V^2 \times \sin 35^\circ \times 3.19 \times l = \text{inch-pounds},$$

and equivalent diameter of stock "d" in inches with a fibre stress k of 5,000 lbs.,

$$d = \sqrt[3]{5.1 \frac{T}{5000}}.$$

The subjoined table gives torsional moments with their equivalent diameters calculated as above, with * 5,000 lbs. per square inch, being a sufficiently high fibre stress to allow for a twisting stress, alternating between right and left, for wrought iron.

In a rudder of rectangular form the centre of pressure from the leading edge is equal to

$$b\,(.195 + .305 \sin a) = \overline{bc},$$

where b is the mean breadth of rudder, and c a coefficient, as under.

Angle of Rudder, a.	c.	Angle of Rudder, a.	c.
10°	.248	35°	.370
20°	.300	40°	.391
30°	.347	45°	.410

Rudder Stocks per Lloyd's Rule.

The following is the formula prescribed by Lloyd's Register for estimating diameters of rudder stocks, but in no case must the result be *less* than the tabulated rule size, which see. It should not, however, be used unless the ship is intended for classification in that society's register, as for very high speed vessels the results obtained would be too weak. One of the factors is draught of water, which has little or no value in computing the strength of rudder stock for a rudder of ordinary type hung on a post. Of course, in a rudder with no bottom bearing, as in destroyers and such craft, the case would be entirely different, as then the stock would be figured for bending, the moment for such being much in excess of the torsional one.

* Take 7,000 lbs. for steel.

Rudder Stock Diameters.

$\frac{\pi}{16} f \cdot d^3$

Torsional Moment "T" in Inch-lbs.	Diameter of Stock in Ins.	Torsional Moment "T" in Inch-lbs.	Diameter of Stock in Ins.	Torsional Moment "T" in Inch-lbs.	Diameter of Stock in Ins.
20,000	2¾	500,000	8	3,250,000	15
25,000	3	550,000	8¼	3,500,000	15⅜
50,000	3¾	600,000	8½	3,750,000	15⅝
75,000	4¼	650,000	8¾	4,000,000	16
100,000	4 11/16	700,000	9	4,250,000	16¼
120,000	5	800,000	9⅜	4,500,000	16⅝
140,000	5¼	900,000	9¾	4,750,000	17
160,000	5½	1,000,000	10	5,000,000	17¼
180,000	5⅝	1,200,000	10⅝	5,500,000	17¾
200,000	5⅞	1,400,000	11¼	6,000,000	18¼
220,000	6	1,600,000	11¾	6,500,000	18⅞
240,000	6¼	1,800,000	12¼	7,000,000	19¼
260,000	6⅜	2,000,000	12⅝	7,500,000	19¾
280,000	6½	2,200,000	13	8,000,000	20⅛
300,000	6¾	2,400,000	13⅝	8,500,000	20⅝
320,000	6⅞	2,600,000	13⅞	9,000,000	21
360,000	7⅛	2,800,000	14¼	9,500,000	21⅜
400,000	7⅜	3,000,000	14½	10,000,000	21¾
450,000	7¾	. . . . .	. . . .	11,000,000	22⅜

NOTE.—Diameters are calculated to nearest eighths of an inch with a fibre stress of 5,000 lbs.

D = draught in feet.
B = greatest distance in inches from centre of pintle to back of rudder.
b = greatest breadth of rudder in inches.
V = speed in knots.
d = diameter of stock in inches.

Then, $$d = \frac{1}{32}\sqrt[3]{Db\,(2\,B - b)\,V^2}.$$

Rudder Stock per Germanischer Lloyd Formula.

This rule is a much more correct one than Lloyd's Register, using, as it does, truer factors. It is given here converted for English measure as well as for metric.

Let d = diameter of stock in centimeters.
F = area of rudder in square meters.
r = distance from centre of gravity of area to axis of stock in centimeters.
V = speed in knots.

Then, $$d = .42\sqrt[3]{FrV^2}.$$

For English measure let

d = diameter of stock in inches.
A = area of rudder in square feet.
r = distance from c.g. to axis in inches.
V = speed in knots.

Then, $$d = .103\sqrt[3]{ArV^2}.$$

British Corporation Formula.

The "B.C.," or British Corporation, Rule is slightly different from the foregoing, but, like it, takes the true factors into account, and gives a more correct result than either of the foregoing formulæ.

$$d = .26\sqrt[3]{rAV^2}.$$

NOTE.—"r" is here taken in feet.

PROPELLER STRUTS.

SIMPSON'S FORMULA.

Propeller "A" brackets or struts are not dealt with in any of the classification societies' rules, and in deciding on a suitable area of section for these, it is the invariable practice to base it on experience. Such being the case, a great divergence is found in the

proportions and dimensions of them in vessels of similar size and power. To insure greater uniformity in their design and weight consistent with ample strength to meet the stresses to which they are subjected, the writer has prepared the formula following, based on the results of a varied experience with struts for all sizes of vessels with a range of I.H.P. of 10 to 7,000 per shaft and revolutions of 70 to 600, and from observation of some which were actually carried away. It should be stated that the smaller powers were not for twin screws but for small craft with cut-away deadwoods necessitating a bracket to support the outer end of shaft. From the formula given, the area is obtained, and with it the following proportions determined :—

SECTION OF ARM

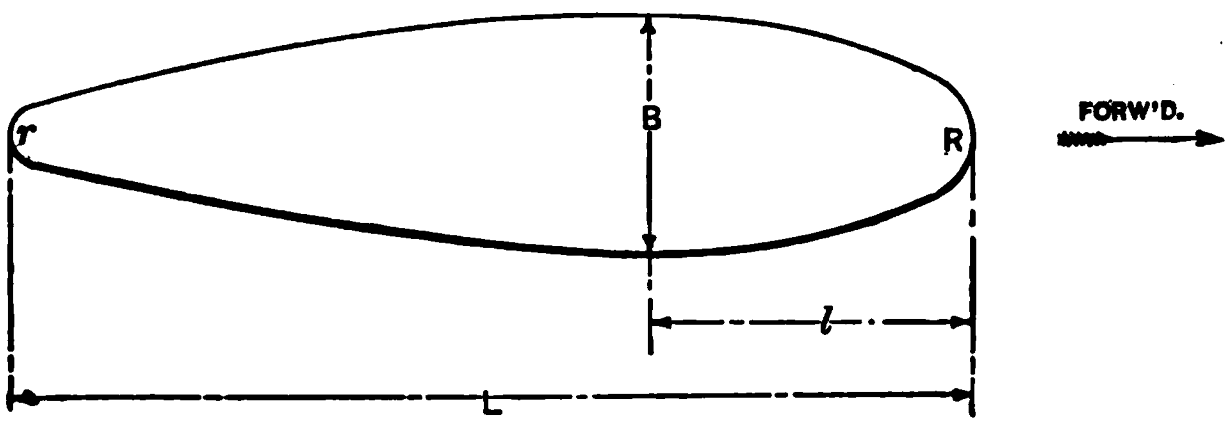


FIG. 38.

Let R = revolutions of engines per minute.
P = indicated horse power.
l = outboard length of shaft from stern tube outer bearing to centre of boss, *in inches*.
k = coefficient = .0633 R.

Then,
$$\frac{\sqrt[3]{R \times P \times l}}{k} = \text{area in square inches.}$$

Of course the horse power is that transmitted through one shaft only, and the area obtained is for one arm. The proportions of the pear-shaped arm are as under.

$$L = \sqrt{5.\dot{3} \times \text{Area.}}$$

$$B = .25\,L. \qquad R = .25\,B.$$
$$l = .33\,L. \qquad r = .50\,R.$$

For the lesser powers and for brackets intended for wood or composite vessels, the brackets should be of gun metal or bronze, and for higher powers and steel ships of cast steel.

Spectacle Frames.

For the larger classes of twin screw steamers what are known as spectacle frames are bolted to body post to take the outer end of shaft, and the shell plating webbed out to enclose what otherwise would be the outboard length of shafting, as described in the chapter on design. These frames are of cast steel and semi-pear-shaped in section. The area of this section may be found from the same formula as if the ship were to be fitted with "*A*"

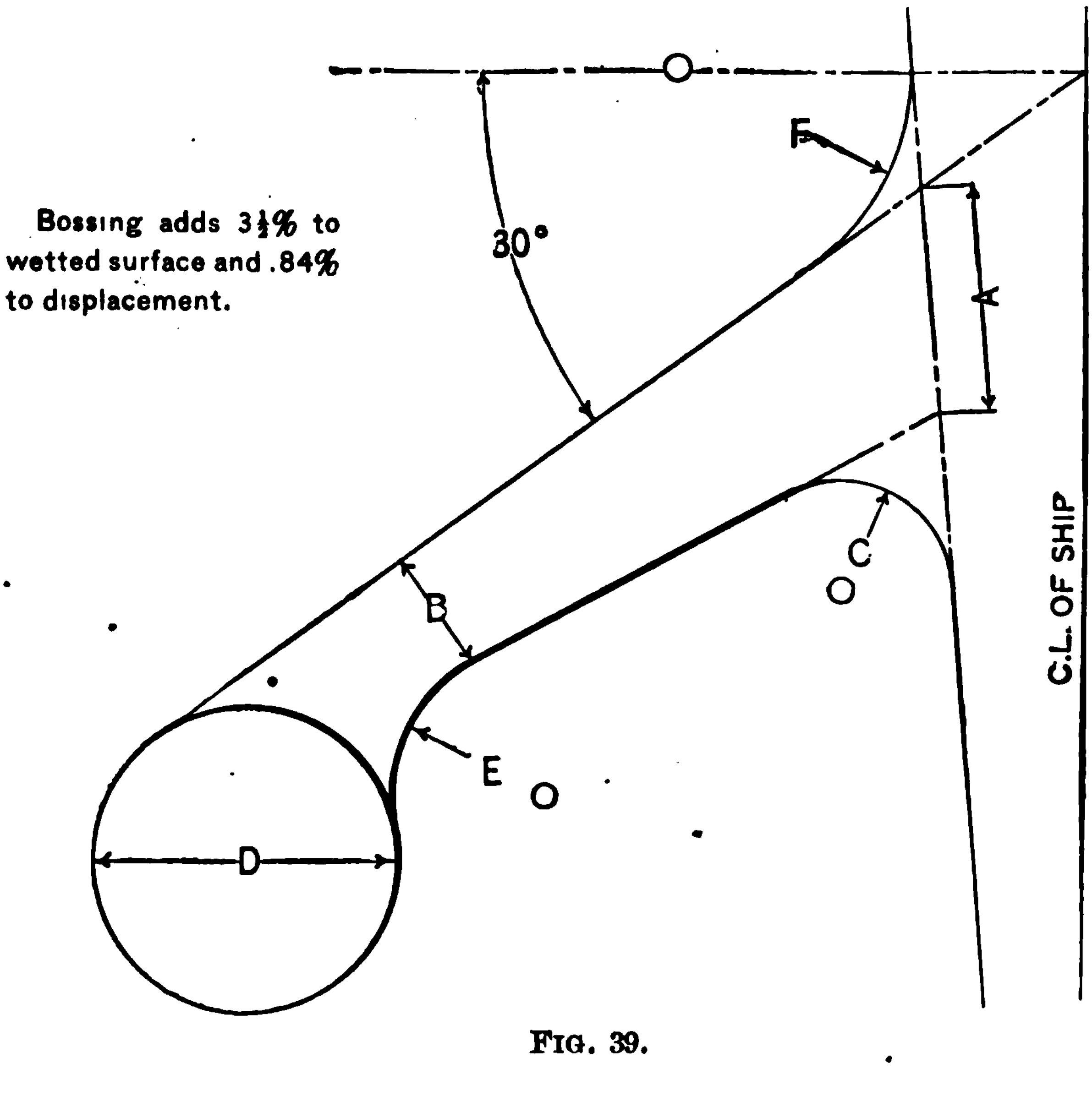


FIG. 39.

brackets and the result multiplied by 2. This greater area is accounted for by the fact that there is only one arm and the greater breadth of same required to permit of working the shell plating and also obtaining the necessary section modulus. The weight, however, will be found to approximate very closely to the open struts. Experiments have shown that better results are obtained by inclining the spectacle frame downwards at an angle of about 30° from the horizontal.

Proportions.

$A = 2L$.
$B = \frac{1}{2}A$.
$C = B$.
$E = \frac{1}{2}D$.
$F = \frac{3}{4}D$.
L = Length of pear-shaped section as got for "A" bracket.

The outside diameter D of the boss will be fixed in conjunction with the engineer.

THE TRANSPORT OF CATTLE.

In arranging the ship for the transport of cattle in conformity with the United States Department of Agriculture, care should be exercised in first providing for the main cattle gangways. A good location for these would be at the ends of engine or boiler casings opposite which the cattle doors should be placed. The webs, webframes, and any other structural obstructions should be arranged with a view to working them in as boundaries for blocks of 4 cattle if practicable, and if the ship be a new one, the frame spacing should be fixed to work out with the legal dimension for cattle pens to obviate waste of space, unsuitable pillaring, and division boards coming off beams. If the ship be of such dimension as to require 30″ spacing ordinarily, then by increasing this to 30½″, a very good arrangement of pens will be obtained. Coaling ports, mucking ports, and all thwartship passages in connection therewith, should next be located, bearing in mind, in arranging these, the 4-cattle blocks previously mentioned. The stalls may be then outlined, followed by the pillars, which, of course, will be placed to suit these, working downwards from the cattle deck to the other hold pillaring.

The following are the dimensions of cattle spaces required by the Department of Agriculture:

Cattle per head on upper, spar, or weather decks:

8′ 0″ long × 2′ 6″ wide × 6′ 0″ high in the clear.

Cattle loaded under decks will require 2 inches more width unless in regular cattle ships with satisfactory ventilation.

Pens must be arranged for 4 cattle, unless at the ends of a row of pens, where 5 may be stowed.

Special permission must be obtained to carry cattle on lower deck, and in all cases where this is granted, the width allotted must be 2′ 8″, the ventilation sufficient, and no animals are allowed on hatches.

Sheep, per head, 4′ 0″ long × 14″ wide in the clear. Pens must not exceed 20 feet × 8 feet where two tiers are carried, and each tier to have a clear vertical space not less than 3 feet.

Horses, per head, 8 feet long × 2′6″ wide × 6′3″ high in the clear, and as far as possible arranged between the overhead athwartship beams. Each horse must have a separate stall, and where 22 or more horses are carried, a hospital 8 feet × 10 feet square must be reserved.

Alleyways for feeding and watering to be 3 feet wide, but where obstructions less than 3 feet long occur, and at ends of ship, they may be reduced to a minimum of 18 inches.

Thwartship alleyways to scuppers to be 18 inches wide.

Headboards not less than 2 × 10 inches or 3 × 8 inches, of spruce or yellow pine.

Footboards, same dimensions as headboards.

Division boards of 2 × 8 inches, spruce or yellow pine fitted vertically for cattle.

Division boards for horses, 2 × 9 inches × 8 feet, planed and placed horizontally.

Footlocks, 2 inches above cement × 4 inches wide of spruce, yellow pine, or hardwood, ranged fore and aft, and placed 12 inches, 14 inches, 26 inches, and 14 inches apart; the first one being 12 inches distant from the inside of footboard; but when troughs are used, the footlocks will be placed 17″, 16″, 22″ and 16″ apart.

Outside planking on open and closed rail ships to be not less than 2 inches spruce or 1½ inches yellow pine.

Ventilators. Each under deck compartment not exceeding 50 feet in length, must have at least four 18-inch diameter cowl ventilators, with tops 7 feet above shelter deck, two being placed at each end of the compartment. If compartments be over 50 feet long, additional ventilators must be fitted.

Weight of Fittings per Head of Cattle Carried.

Item.	Weight in Lbs.
Cementing on deck 1½″ thick	185.00
Total woodwork, including bolts	139.62
Angle steel footlock clips	11.43
Castings and fittings, including bolts	37.19
Gnawing strips of segmental iron	6.00
Solid cattle pillars	9.74
Hollow cattle pillars	11.02
Total per head of cattle	=400.00

ight. Sufficient light must be provided for the proper tending nimals at all times.

entilation for horses. Under deck canvas bags should be fitted rentilators, provided with iron rings at bottom, and reaching hin 18 inches of the deck under foot.

n estimating the *weight* of cattle fittings, comprising cement, tle pillars, footlocks, head and rumpboards, castings, etc., the owing will be found reliable :—

Weight of Fittings per Horse Carried.

Item.	Weight in Lbs.
Cementing on deck 1½″ thick	185.00
Total woodwork, including bolts	273.55
Kicking pieces and bolts	34.11
Castings and fittings, including bolts . . .	200.34
Total per horse (London regulation). .	=693.00
Leaving an American port, deduct close division boards	135.00
Total per horse (American regulation)	=558.00

WEIGHT OF HULL.

n estimating for displacement purposes, the weight of a ship's l is usually divided broadly into two parts, viz.: (1) finished l and (2) weight of wood and outfit.

here are various methods by which the steel may be estimated roximately, but where great accuracy is required the weights the structure should be calculated in detail systematically, and results summarized in convenient form for future reference.

he arrangement shown in the table will be found useful when cost estimate is being figured, as the parts of structure item-l are those which generally show variations in labor prices. summary of material is given for a similar reason, and also the variation in scrap between the different items.

f course the structural parts considered in the table must each lealt with in detail, but by having some such form as that e presented the chances of omission will be minimized, the ghts put in a convenient form for prime cost, and also usefully inged if the centre of gravity should afterwards require calcu-ng.

he most common method to approximate the weights of hull l when there is insufficient time to figure in detail, is to take ratio between the weight and the cubic number of a known

Calculated Finished Steel Weight.

Reference Number.	Part of Structure.	S.S. 430′ × 46′ × 34½′ Lloyd's 3-Deck Rule.	Summary.	
		Tons.		Tons.
1	Keel bars and stem	3.5	Forgings .	6.0
2	Stern post, rudder frame and struts	20.0	Angles . .	587.0
3	Frames, reverse frames, and doublings	275.0	Plates . .	2063.6
4	Floors and tail plates . . .	301.0		
5	Beams and carlings . . .	225.4	Bulb tee .	168.4
6	Keelsons	142.5		
7	Bulkheads (W.T.)	102.7	Slips . .	57.0
8	Bunker casings	40.0		
9	Engine and boiler seats . .	25.0	Mouldings	46.5
10	Shaft tunnel and stools . .	37.7		
11	Inner bottom plating . . .	119.4	Castings .	17.5
12	Shell plating, including bhd. liners	734.2	Rivet heads	44.0
13	Stringers and ties	217.6		
14	Deck plating	305.3	Total	= 2990.0
15	Cargo and coal hatches . .	37.5		
16	Engine and boiler casings .	77.6		
17	Deck houses	140.0		
18	Sundry deck and hold work .	25.0		
19	Fresh-water tanks	13.2		
20	Slip iron	57.0		
21	Moulding and copes . . .	46.5		
22	Rivet heads	44.0		
	Finished steel weight . =	2990.0		

vessel of similar type and degree of fineness and use the coefficient so obtained on the proposed ship. For example, a known ship of length 330 feet, breadth 41′ 9″, and depth moulded 28′ 3″, has a total steel weight of 1,680 tons, then

$$\frac{L \times B \times D}{S \times 100} = \frac{330 \times 41.75 \times 28.25}{1680 \times 100} = .431 \text{ coefficient.}$$

The proposed steamer is $320 \times 42 \times 29\frac{1}{2}$ and the coefficient of steel weight being .431, we get

$$\frac{320 \times 42 \times 29\frac{1}{2}}{100} \times .431 = 1709 \text{ tons.}$$

This rough method requires good judgment and practice, as it is obvious from the example given that although 1,709 tons is a fair approximation it is still too heavy.

Recognizing this fact and the necessity for a quick approximative rule which would give fairly close results, Mr. J. Johnson (*vide* Trans. Inst. Nav. Arch. Vol. 39) devised a method based on Lloyd's longitudinal number (modified for some types) and by plotting down known steel weights opposite their numeral, drawing curves through the mean values of each type, he analyzed them and found their equations. By means of curves prepared in this way from actual weights, the amount of steel is easily read off and the increase or decrease due to an alteration in the numeral is readily seen. Johnson's formula is as under,

$$W = cN^{\chi} \text{ or } W = K\left(\frac{N}{100}\right)^{\chi};$$

where

W = Finished weight in tons of iron or steel used in hull construction.

N = Lloyd's longitudinal number modified as follows: In 3 decked vessels the girths and depths are measured to the upper deck without deduction. In spar and awning decked vessels the girths and depths are measured to the spar or awning decks respectively.

In one, two or well decked vessels the girths and depths are taken to the main deck in the usual way.

c and K are coefficients varying with different types.

χ is an exponent, also varying with different types.

Table Giving the Mean Values for c, K, and χ for Vessels Built to Lloyd's or Veritas' Highest Class.

Type of Vessel.	*c.*	*K.*	χ.
Three deck, with complete shelter deck	.00359	.328	1.48
Three deck	.00078	.492	1.40
Spar deck	.00115	.576	1.35
Awning deck	.00167	.665	1.30
One deck, two deck, and well deck .	.00215	.856	1.30
Sailing vessels	.00065	.410	1.40

Of course differences in the arrangement of scantlings, extent of double bottom, number of bulkheads or length of erections must be calculated as extra.

A complete set of curves based on this method, but extended to embrace the largest types of vessels including complete shelter deck steamers is given opposite.

The second part of the finished hull weight, viz.: the wood and outfit, embraces everything that goes to finish the ship excepting fresh water, coal and consumable stores. That is, it comprises all wood work, both shipwright and joiner, masts, rigging, sails, boats, anchors, chains, cables, hawsers, furniture, fixtures, etc., many of the items being extremely difficult of accurate calculation. For this reason it is necessary where these fittings are calculated in detail to carefully check the result obtained by a similar method to that used for the approximated steel weight from actual wood outfit data derived from known ships of similar type. The value of this coefficient for various classes will be seen from the Table of Elements of Ships.

Regarding this weight, Johnson states that it will be found to vary almost directly as the longitudinal number.

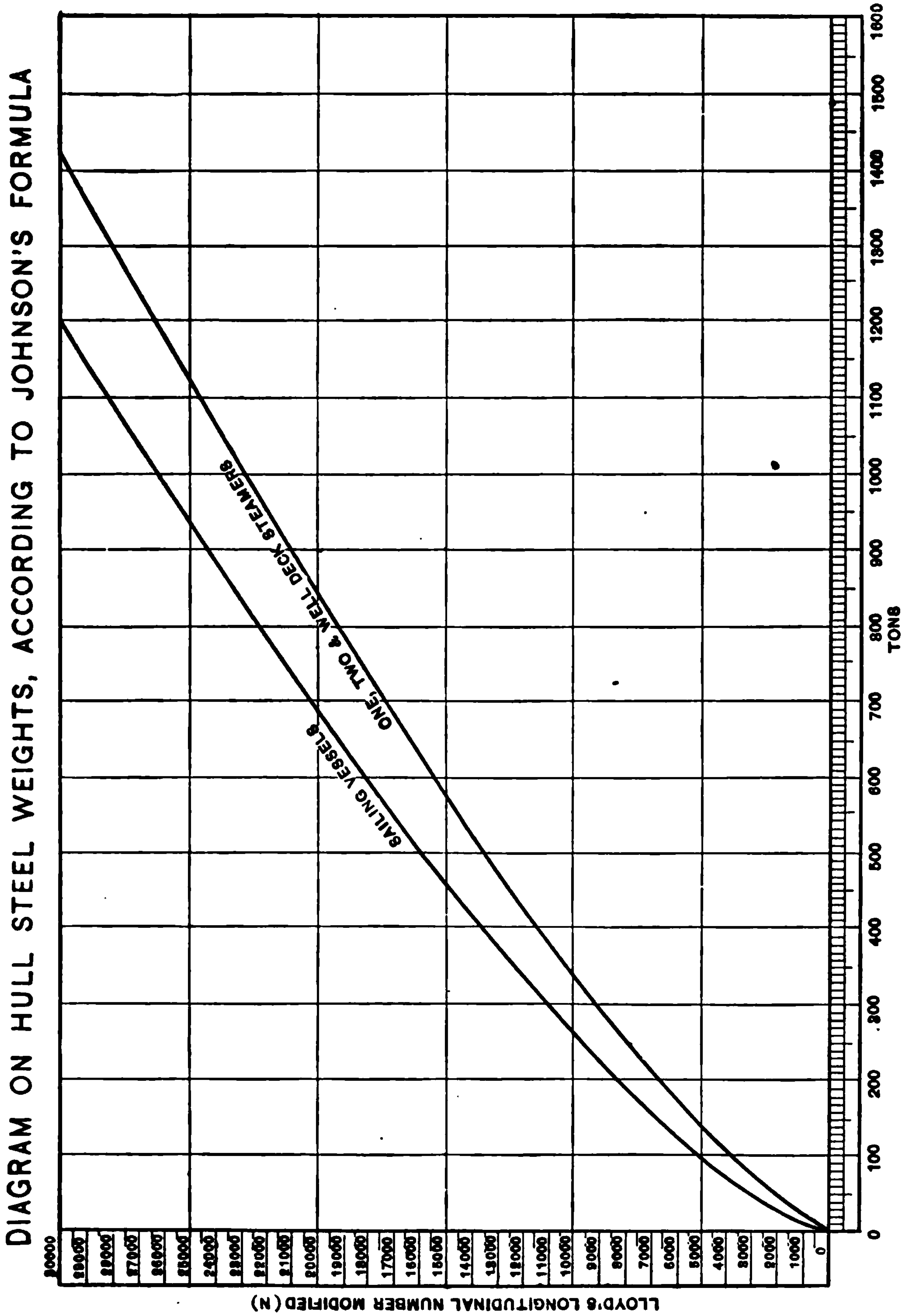


DIAGRAM ON HULL STEEL WEIGHTS, ACCORDING TO JOHNSON'S FORMULA
ONE, TWO & WELL DECK STEAMERS
SAILING VESSELS
TONS
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
LLOYD'S LONGITUDINAL NUMBER MODIFIED (N)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
15000
16000
17000
18000
19000
20000
21000
22000
23000
24000
25000
26000
27000
28000
29000
30000

FIG. 40.

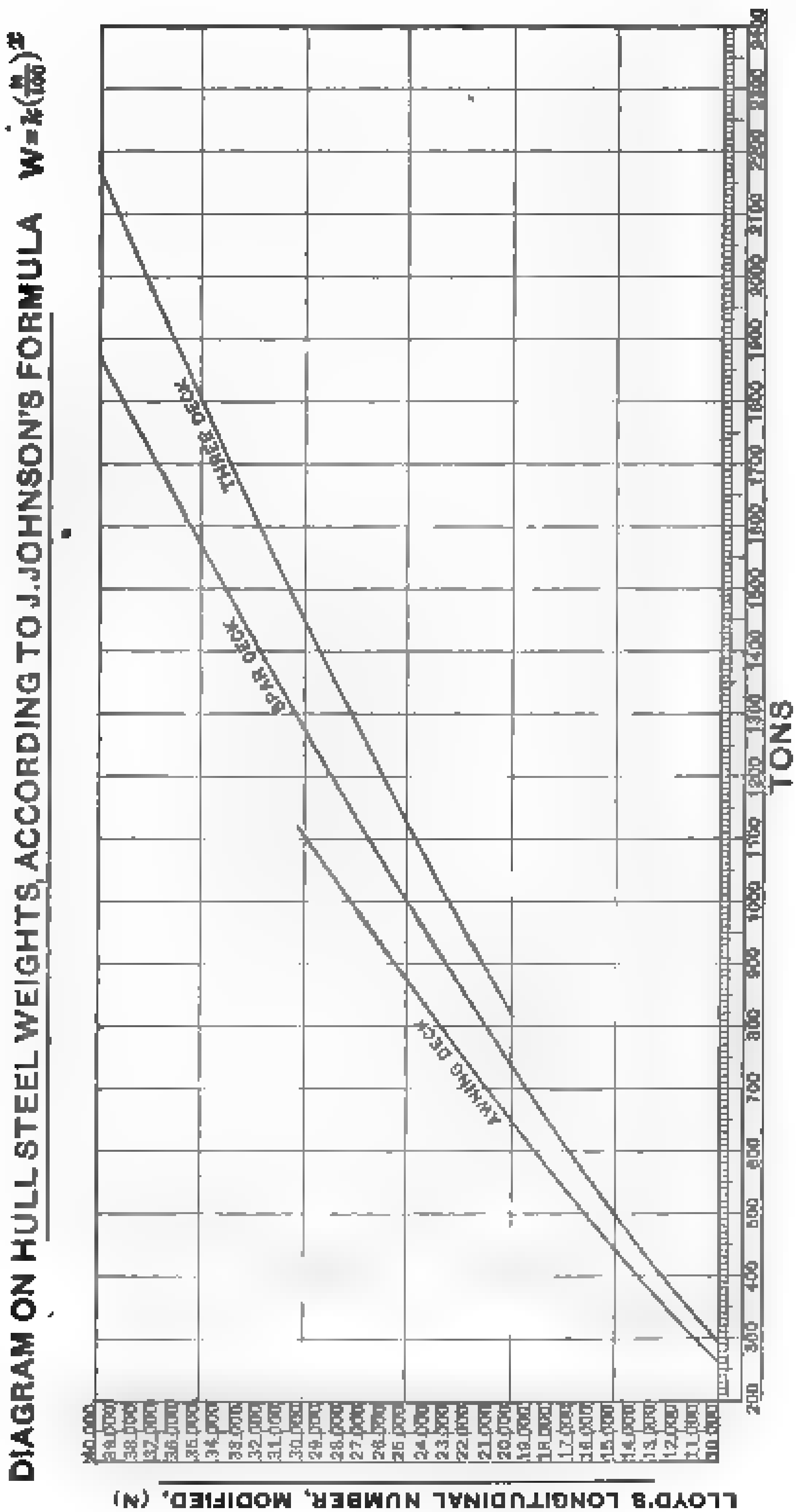


DIAGRAM ON HULL STEEL WEIGHTS ACCORDING TO J. JOHNSON'S FORMULA W = k(N/1000)²
THREE DECK
SPAR DECK
AWNING DECK
TONS
LLOYD'S LONGITUDINAL NUMBER, MODIFIED, (N)

FIG. 41.

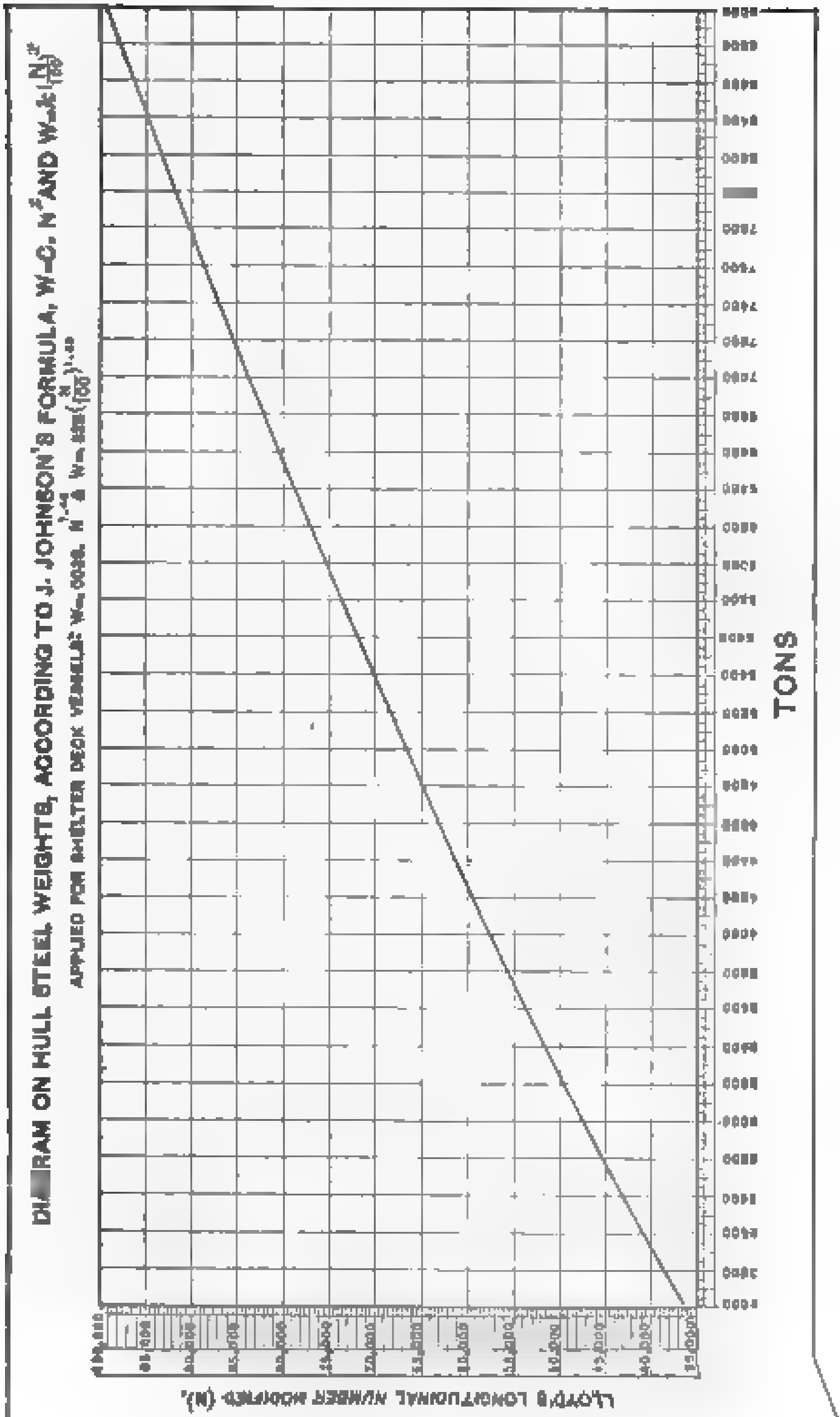


FIG. 42.

STEEL SHIPBUILDING SECTIONS. — ANGLES.

Weight in Pounds per Foot Run.

Sum of Breadth of Flanges	Thickness in Twentieths of an Inch.																			
	$\frac{1}{20}$	$\frac{2}{20}$	$\frac{3}{20}$	$\frac{4}{20}$	$\frac{5}{20}$	$\frac{6}{20}$	$\frac{7}{20}$	$\frac{8}{20}$	$\frac{9}{20}$	$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{13}{20}$	$\frac{14}{20}$	$\frac{15}{20}$	$\frac{16}{20}$	$\frac{17}{20}$	$\frac{18}{20}$	$\frac{19}{20}$	$\frac{20}{20}$
1	.16	.31	.43	.54	.64	.71									..		..	.	..	.
1⅛	.18	.35	.50	.63	.74	.84											..	.	..	..
1¼	.20	.39	.56	.71	.85	.97	1.07										..	.	..	.
1⅜	.23	.43	.62	.80	.96	1.10	1.22									..	..		..	..
1½	.25	.48	.69	.88	1.06	1.22	1.37	1.50			..	..					..		..	..
1⅝	.27	.52	.75	.97	1.17	1.35	1.52	1.67				..	..				..	..	..	..
1¾	.29	.56	.82	1.05	1.27	1.48	1.67	1.84	1.99							..	..	..	..	.
1⅞	.31	.60	.88	1.14	1.38	1.61	1.81	2.01	2.18	...					..		..		..	..
2	.33	.65	.94	1.22	1.49	1.73	1.96	2.18	2.37	2.55		...					..	..	..	..
2⅛	.35	.69	1.01	1.31	1.59	1.86	2.11	2.35	2.56	2.76							..		..	..
2¼	.37	.73	1.07	1.39	1.70	1.99	2.26	2.52	2.75	2.98	..	...					..	..	..	..
2⅜	.40	.77	1.13	1.48	1.81	2.12	2.41	2.69	2.95	3.19	..	..	..	..		..	..	..	..	..
2½	.42	.82	1.20	1.56	1.91	2.24	2.56	2.89	3.14	3.40	3.65	...	..	..	..		..	..	..	..
2⅝	.44	.86	1.26	1.65	2.02	2.37	2.71	3.03	3.33	3.61	3.88	...	..	..		..	..	..	..	..
2¾	.46	.90	1.33	1.73	2.13	2.50	2.86	3.20	3.52	3.83	4.11	...	..	..	..	..	..	..	..	..
2⅞	.48	.94	1.39	1.82	2.23	2.63	3.00	3.37	3.71	4.04	4.36	...	..	..	..	..	..	..	..	..

Sum of Breadth of Flanges.	Thickness in Twentieths of an Inch.																			
	1/20	2/20	3/20	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
3	.50	.99	1.45	1.90	2.34	2.75	3.15	3.54	3.90	4.25	4.58	4.90								
3⅛	.52	1.03	1.52	1.99	2.44	2.88	3.30	3.71	4.09	4.46	4.82	5.15								
3¼	.54	1.07	1.58	2.07	2.55	3.01	3.45	3.88	4.28	4.68	5.05	5.41								
3⅜	.57	1.11	1.64	2.16	2.66	3.14	3.60	4.05	4.48	4.89	5.28	5.66								
3½	.59	1.16	1.71	2.24	2.76	3.26	3.75	4.22	4.67	5.10	5.52	5.92	6.3							
3⅝	.61	1.20	1.77	2.33	2.87	3.39	3.90	4.39	4.86	5.31	5.75	6.17	6.6							
3¾	.63	1.24	1.84	2.41	2.98	3.52	4.05	4.56	5.05	5.53	5.98	6.43	6.9							
3⅞	.65	1.28	1.90	2.50	3.08	3.65	4.19	4.73	5.24	5.74	6.22	6.68	7.1							
4	.67	1.33	1.96	2.58	3.19	3.77	4.34	4.90	5.43	5.95	6.45	6.94	7.4	7.9						
4⅛	.69	1.37	2.03	2.67	3.29	3.90	4.49	5.07	5.62	6.16	6.69	7.19	7.7	8.2						
4¼	.71	1.41	2.09	2.75	3.40	4.03	4.64	5.24	5.81	6.38	6.92	7.45	8.0	8.4						
4⅜	.74	1.45	2.15	2.84	3.51	4.16	4.79	5.41	6.01	6.59	7.15	7.70	8.2	8.7						
4½	.76	1.50	2.22	2.92	3.61	4.28	4.94	5.58	6.20	6.80	7.39	7.96	8.5	9.0	9.6					
4⅝	.78	1.54	2.28	3.01	3.72	4.41	5.09	5.75	6.39	7.01	7.62	8.21	8.9	9.3	9.9					
4¾	.80	1.58	2.35	3.09	3.83	4.54	5.24	5.92	6.58	7.23	7.85	8.47	9.1	9.6	10.2					
4⅞	.82	1.62	2.41	3.18	3.93	4.67	5.38	6.09	6.77	7.44	8.09	8.72	9.3	9.9	10.5					
5	.84	1.67	2.47	3.26	4.04	4.79	5.53	6.26	6.96	7.65	8.32	8.98	9.6	10.2	10.8	11.4				
5⅛	.86	1.71	2.54	3.35	4.14	4.92	5.68	6.43	7.15	7.86	8.56	9.23	9.9	10.5	11.2	11.8				
5¼	.88	1.75	2.60	3.43	4.25	5.05	5.83	6.60	7.34	8.08	8.79	9.49	10.2	10.8	11.5	12.1				
5⅜	.91	1.79	2.66	3.52	4.36	5.18	5.98	6.77	7.54	8.29	9.02	9.74	10.4	11.1	11.8	12.4				
5½	.93	1.84	2.73	3.60	4.46	5.30	6.13	6.94	7.73	8.50	9.26	10.00	10.7	11.4	12.1	12.8	13.4			
5⅝	.95	1.88	2.79	3.69	4.57	5.43	6.28	7.11	7.92	8.71	9.49	10.25	11.0	11.7	12.4	13.1	13.8			
5¾	.97	1.92	2.86	3.77	4.68	5.56	6.43	7.28	8.11	8.93	9.72	10.51	11.3	12.0	12.7	13.5	14.2			
5⅞	.99	1.96	2.92	3.86	4.78	5.69	6.57	7.45	8.30	9.14	9.96	10.76	11.5	12.3	13.1	13.8	14.5			

THICKNESS IN TWENTIETHS OF AN INCH.

Sum of Breadth of Flanges	1/20	2/20	3/20	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
6	1.01	2.01	2.98	3.94	4.89	5.81	6.72	7.62	8.49	9.35	10.19	11.02	11.8	12.6	13.4	14.1	14.9	15.6	..	..
6⅛	1.03	2.05	3.05	4.03	4.99	5.96	6.87	7.79	8.68	9.56	10.43	11.27	12.1	12.9	13.7	14.5	15.2	16.0	..	..
6¼	1.05	2.09	3.11	4.11	5.10	6.07	7.02	7.96	8.87	9.78	10.66	11.53	12.4	13.2	14.0	14.8	15.6	16.4	..	..
6⅜	1.08	2.13	3.17	4.20	5.21	6.20	7.17	8.13	9.07	9.99	10.89	11.78	12.7	13.5	14.3	15.2	16.0	16.8	.	..
6½	1.10	2.18	3.24	4.28	5.31	6.32	7.32	8.30	9.26	10.20	11.13	12.04	12.9	13.8	14.7	15.5	16.3	17.1	17.9	..
6⅝	1.12	2.22	3.30	4.37	5.42	6.45	7.47	8.47	9.45	10.41	11.36	12.29	13.2	14.1	15.0	15.8	16.7	17.5	18.3	..
6¾	1.14	2.26	3.37	4.45	5.53	6.58	7.62	8.64	9.64	10.63	11.59	12.55	13.5	14.4	15.3	16.2	17.5	17.9	18.7	.
6⅞	1.16	2.30	3.43	4.54	5.63	6.71	7.76	8.81	9.83	10.84	11.83	12.80	13.8	14.7	15.6	16.5	17.4	18.3	19.1	..
7	1.18	2.35	3.49	4.62	5.74	6.83	7.91	8.98	10.02	11.05	12.06	13.06	14.0	15.0	15.9	16.9	17.8	18.7	19.5	20.4
7⅛	1.20	2.39	3.56	4.71	5.84	6.96	8.06	9.15	10.21	11.26	12.30	13.31	14.3	15.3	16.3	17.2	18.1	19.0	19.9	20.8
7¼	1.22	2.43	3.62	4.79	5.95	7.09	8.21	9.32	10.40	11.48	12.53	13.57	14.6	15.6	16.6	17.5	18.5	19.4	20.3	21.2
7⅜	1.25	2.47	3.68	4.88	6.06	7.22	8.36	9.49	10.60	11.69	12.76	13.82	14.9	15.9	16.9	17.9	18.9	19.8	20.8	21.7
7½	1.27	2.52	3.75	4.96	6.16	7.34	8.51	9.66	10.79	11.90	13.00	14.08	15.1	16.2	17.2	18.2	19.2	20.2	21.2	22.1
7⅝	1.29	2.56	3.81	5.05	6.27	7.47	8.66	9.83	10.98	12.11	13.23	14.33	15.4	16.5	17.5	18.6	19.6	20.6	21.6	22.5
7¾	1.31	2.60	3.88	5.13	6.38	7.60	8.81	10.00	11.17	12.33	13.46	14.59	15.7	16.8	17.9	18.9	19.9	21.0	22.0	22.9
7⅞	1.33	2.64	3.94	5.22	6.48	7.73	8.95	10.17	11.36	12.56	13.70	14.84	16.0	17.1	18.2	19.2	20.3	21.3	22.4	23.4
8	1.35	2.69	4.00	5.30	6.59	7.85	9.10	10.34	11.55	12.75	13.93	15.10	16.2	17.4	18.5	19.6	20.7	21.7	22.8	23.8
8⅛		2.73	4.07	5.39	6.69	7.98	9.25	10.51	11.74	12.96	14.17	15.35	16.5	17.7	18.8	19.9	21.0	22.1	23.2	24.2
8¼		2.77	4.13	5.47	6.80	8.11	9.40	10.68	11.93	13.18	14.40	15.61	16.8	18.0	19.1	20.3	21.4	22.5	23.6	24.6
8⅜		2.81	4.19	5.56	6.91	8.24	9.55	10.85	12.13	13.39	14.63	15.86	17.1	18.3	19.4	20.6	21.8	22.9	24.0	25.1
8½		2.86	4.26	5.64	7.01	8.36	9.70	11.02	12.32	13.60	14.87	16.12	17.3	18.6	19.8	20.9	22.1	23.3	24.4	25.5
8⅝		2.90	4.32	5.73	7.12	8.49	9.85	11.19	12.51	13.81	15.10	16.37	17.6	18.9	20.1	21.3	22.5	23.6	24.8	25.9
8¾		2.94	4.39	5.81	7.23	8.62	10.00	11.36	12.70	14.03	15.33	16.63	17.9	19.2	20.4	21.6	22.8	24.0	25.2	26.3
8⅞		2.98	4.45	5.90	7.33	8.75	10.14	11.53	12.89	14.24	15.57	16.88	18.2	19.5	20.7	22.0	23.2	24.4	25.6	26.7

Sum of Breadth of Flanges.	Thickness in Twentieths of an Inch.																			
	1/20	2/20	3/20	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
9		3.08	4.51	5.98	7.44	8.87	10.29	11.70	13.08	14.45	15.80	17.14	18.5	19.8	21.0	22.3	23.6	24.8	26.0	27.2
9⅛			4.58	6.07	7.54	9.00	10.44	11.87	13.27	14.66	16.04	17.39	18.7	20.1	21.4	22.6	23.9	25.2	26.4	27.6
9¼			4.64	6.15	7.65	9.13	10.59	12.04	13.46	14.88	16.27	17.65	19.0	20.3	21.7	23.0	24.3	25.6	26.8	28.0
9⅜			4.70	6.24	7.76	9.26	10.74	12.11	13.60	15.09	16.50	17.90	19.3	20.6	22.0	23.3	24.6	25.9	27.2	28.5
9½			4.77	6.32	7.86	9.38	10.89	12.38	13.85	15.30	16.74	18.16	19.6	20.9	22.3	23.7	25.0	26.3	27.6	28.9
9⅝			4.83	6.41	7.97	9.51	11.04	12.55	14.04	15.51	16.97	18.41	19.8	21.2	22.6	24.0	25.4	26.7	28.0	29.3
9¾			4.90	6.49	8.08	9.64	11.19	12.72	14.23	15.73	17.20	18.67	20.1	21.5	22.9	24.3	25.7	27.1	28.4	29.7
9⅞			4.96	6.58	8.18	9.77	11.33	12.89	14.42	15.94	17.44	18.92	20.4	21.8	23.3	24.7	26.1	27.5	28.8	30.2
10				6.66	8.29	9.89	11.48	13.06	14.61	16.15	17.67	19.18	20.7	22.1	23.6	25.0	26.4	27.8	29.2	30.6
10⅛				6.75	8.39	10.20	11.63	13.23	14.80	16.36	17.91	19.43	20.9	22.4	23.9	25.4	26.8	28.2	29.6	31.0
10¼				6.83	8.50	10.15	11.78	13.40	14.99	16.58	18.14	19.69	21.2	22.7	24.2	25.7	27.2	28.6	30.0	31.4
10⅜				6.92	8.61	10.28	11.94	13.57	15.19	16.79	18.37	19.94	21.5	23.0	24.5	26.0	27.5	29.0	30.4	31.9
10½				7.00	8.71	10.40	12.08	13.74	15.38	17.00	18.61	20.20	21.8	23.3	24.9	26.4	27.9	29.4	30.8	32.3
10⅝				7.09	8.82	10.53	12.23	13.91	15.57	17.21	18.84	20.45	22.0	23.6	25.2	26.7	28.2	29.8	31.3	32.7
10¾				7.17	8.93	10.66	12.38	14.08	15.76	17.43	19.07	20.71	22.3	23.9	25.5	27.1	28.6	30.1	31.7	33.1
10⅞				7.26	9.03	10.79	12.52	14.25	15.95	17.64	19.31	20.96	22.6	24.2	25.8	27.4	29.0	30.5	32.1	33.6
11				7.34	9.14	10.91	12.67	14.42	16.14	17.85	19.54	21.22	22.9	24.5	26.1	27.7	29.3	30.9	32.5	34.0
11⅛					9.24	11.04	12.82	14.59	16.33	18.06	19.78	21.47	23.1	24.8	26.5	28.1	29.7	31.3	32.9	34.4
11¼					9.35	11.17	12.97	14.76	16.52	18.28	20.01	21.73	23.4	25.1	26.8	28.4	30.1	31.7	33.3	34.8
11⅜					9.46	11.30	13.12	14.93	16.72	18.49	20.24	21.98	23.7	25.4	27.1	28.8	30.4	32.1	33.7	35.3
11½					9.56	11.42	13.27	15.10	16.91	18.70	20.48	22.24	24.0	25.7	27.4	29.1	30.8	32.4	34.1	35.7
11⅝					9.67	11.55	13.42	15.27	17.10	18.91	20.71	22.49	24.3	26.0	27.7	29.4	31.1	32.8	34.5	36.1
11¾					9.78	11.68	13.57	15.44	17.29	19.13	20.94	22.75	24.5	26.3	28.0	29.8	31.5	33.2	34.9	36.5
11⅞					9.88	11.81	13.71	15.61	17.48	19.34	21.18	23.00	24.8	26.6	28.4	30.1	31.9	33.6	35.3	37.0

Sum of Breadth of Flanges.	1/20	2/20	3/20	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
										Thickness in Twentieths of an Inch.										
12					9.99	11.93	13.86	15.78	17.67	19.55	21.41	23.26	25.1	26.9	28.7	30.5	32.2	34.0	35.7	37.4
12⅛						12.06	14.01	15.95	17.86	19.76	21.65	23.51	25.4	27.2	29.0	30.8	32.6	34.3	36.1	37.8
12¼						12.19	14.16	16.12	18.05	19.98	21.88	23.77	25.6	27.5	29.3	31.1	32.9	34.7	36.5	38.2
12⅜						12.32	14.31	16.29	18.26	20.19	22.11	24.02	25.9	27.8	29.6	31.5	33.3	35.1	36.9	38.7
12½						12.44	14.46	16.46	18.44	20.40	22.35	24.28	26.2	28.1	30.0	31.8	33.7	35.5	37.3	39.1
12⅝						12.57	14.61	16.63	18.63	20.61	22.58	24.53	26.5	28.4	30.3	32.2	34.0	35.9	37.7	39.5
12¾						12.70	14.76	16.80	18.82	20.83	22.81	24.79	26.7	28.7	30.6	32.5	34.4	36.3	38.1	39.9
12⅞						12.83	14.90	16.97	19.01	21.04	23.04	25.04	27.0	29.0	30.9	32.8	34.8	36.6	38.5	40.4
13						12.95	15.05	17.14	19.20	21.25	23.28	25.30	27.3	29.3	31.2	33.2	35.1	37.0	38.9	40.8
13⅛							15.20	17.31	19.39	21.46	23.52	25.55	27.6	29.6	31.6	33.5	35.5	37.4	39.3	41.2
13¼							...	17.48	19.58	21.68	23.75	25.81	27.8	29.9	31.9	33.9	35.8	37.8	39.7	41.6
13⅜						..	...	17.65	19.78	21.89	23.98	26.06	28.1	30.2	32.2	34.2	36.2	38.2	40.1	42.1
13½						...	...	17.82	19.97	22.10	24.22	26.32	28.4	30.5	32.5	34.5	36.6	38.6	40.5	42.5
13⅝						..	...	17.99	20.16	22.31	24.45	26.57	28.7	30.8	37.8	34.9	36.9	38.9	40.9	42.9
13¾						.	..	18.16	20.35	22.53	24.68	26.83	29.0	31.1	33.1	35.2	37.3	39.3	41.3	43.3
13⅞						..	..	18.33	20.54	22.74	24.92	27.08	29.2	31.4	33.5	35.6	37.6	39.7	41.7	43.8
14								18.50	20.73	22.95	25.15	27.34	29.5	31.7	33.8	35.9	38.0	40.1	42.2	44.2
14⅛								18.67	20.92	23.16	25.39	27.59	29.8	32.0	34.1	36.2	38.4	40.5	42.6	44.6
14¼							..	18.84	21.11	23.38	25.62	27.85	30.1	32.2	34.4	36.6	38.7	40.9	43.0	45.0
14⅜								19.01	21.31	23.59	25.85	28.10	30.3	32.5	34.7	36.9	39.1	41.2	43.4	45.5
14½							..	19.18	21.50	23.80	26.09	28.36	30.6	32.8	35.1	37.3	39.4	41.6	43.8	45.9
14⅝								19.35	21.69	24.01	26.32	28.61	30.9	33.1	35.4	37.6	39.8	42.0	44.2	46.3
14¾								19.52	21.88	24.23	26.55	28.87	31.2	33.4	35.7	37.9	40.2	42.4	44.6	46.7
14⅞		..	..		..	..		19.69	22.07	24.44	26.79	29.12	31.4	33.7	36.0	38.3	40.5	42.8	45.0	47.2
15			..	..	..	..		19.86	22.26	24.65	27.02	29.38	31.7	34.0	36.3	38.6	40.9	43.1	45.4	47.6

STEEL SHIPBUILDING SECTIONS. — TEE BAR.

Weight in Pounds per Foot Run.

Sum of Breadth of Flanges.	Thickness in Twentieths of an Inch.																			
	$\frac{1}{20}$	$\frac{2}{20}$	$\frac{3}{20}$	$\frac{4}{20}$	$\frac{5}{20}$	$\frac{6}{20}$	$\frac{7}{20}$	$\frac{8}{20}$	$\frac{9}{20}$	$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{13}{20}$	$\frac{14}{20}$	$\frac{15}{20}$	$\frac{16}{20}$	$\frac{17}{20}$	$\frac{18}{20}$	$\frac{19}{20}$	$\frac{20}{20}$
1	.16	.32	.45	.57	.69	.78	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$1\frac{1}{8}$	.18	.36	.52	.66	.79	.91	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$1\frac{1}{4}$	.20	.40	.58	.74	.90	1.04	1.16	...	...	...	...	...	...	...	...	...	...	...	...	...
$1\frac{3}{8}$	.23	.44	.64	.83	1.01	1.17	1.31	...	...	...	...	...	...	...	...	...	...	...	...	...
$1\frac{1}{2}$	.25	.49	.71	.91	1.11	1.29	1.46	1.62	...		...	...	...	...	...	...	...	...	...	...
$1\frac{5}{8}$	.27	.53	.77	1.00	1.22	1.42	1.61	1.79	...	...	...	...	...	...	...	...	...	...	...	...
$1\frac{3}{4}$	.29	.57	.84	1.08	1.32	1.55	1.76	1.96	2.14	...	...	...	...	...	...	...	...	...	...	...
$1\frac{7}{8}$	.31	.61	.90	1.17	1.43	1.68	1.90	2.13	2.33	...	...	...	...	...	...	...	...	...	...	...
2	.33	.66	.96	1.25	1.54	1.80	2.05	2.30	2.52	2.74	...	...	...	...	...	...	...	...	...	...
$2\frac{1}{8}$	.35	.70	1.03	1.34	1.64	1.93	2.20	2.47	2.71	2.95	...	...	...	...	...	...	...	...	...	...
$2\frac{1}{4}$	.37	.74	1.09	1.42	1.75	2.06	2.35	2.64	2.90	3.17	...	...	...	...	...	...	...	...	...	...
$2\frac{3}{8}$	.40	.78	1.15	1.51	1.86	2.19	2.50	2.81	3.10	3.38	...	...	...	...	...	...	...	...	...	...
$2\frac{1}{2}$	.42	.83	1.22	1.59	1.96	2.31	2.65	2.98	3.29	3.59	3.87	...	...	...	...	...	...	...	...	...
$2\frac{5}{8}$	.44	.87	1.28	1.68	2.07	2.44	2.80	3.15	3.48	3.80	4.10	...	...	...	...	...	...	...	...	...
$2\frac{3}{4}$	.46	.91	1.35	1.76	2.18	2.57	2.95	3.32	3.67	4.02	4.33	...	...	...	...	...	...	...	...	...
$2\frac{7}{8}$	.48	.95	1.41	1.85	2.28	2.70	3.09	3.49	3.86	4.23	4.57	...	...	...	...	...	...	...	...	...

Sum of Breadth of Flanges.	Thickness in Twentieths of an Inch.																			
	1/20	2/20	3/20	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
3	.50	1.00	1.47	1.93	2.39	2.82	3.24	3.66	4.05	4.44	4.80	5.16	..	..	..	..	..	..	..	..
3⅛	.52	1.04	1.54	2.02	2.49	2.95	3.39	3.83	4.24	4.65	5.04	5.41	.	..	..	..	..	..	..	..
3¼	.54	1.08	1.60	2.10	2.60	3.08	3.54	4.00	4.43	4.87	5.27	5.67	..	..	..	..	..	..	..	..
3⅜	.57	1.12	1.66	2.19	2.71	3.21	3.69	4.17	4.63	5.08	5.50	5.92		.	.	..	..	..	..	..
3½	.59	1.17	1.73	2.27	2.81	3.33	3.84	4.34	4.82	5.29	5.74	6.18	6.6	..	..	..	..	..	..	..
3⅝	.61	1.21	1.79	2.36	2.92	3.46	3.99	4.51	5.01	5.50	5.97	6.43	6.9	.	..	..	..	..	..	..
3¾	.63	1.25	1.86	2.44	3.03	3.59	4.14	4.68	5.20	5.72	6.20	6.69	7.2	..	..	..	..	..	..	..
3⅞	.65	1.29	1.92	2.53	3.13	3.72	4.28	4.85	5.39	5.93	6.44	6.94	7.4	..	..	..	..	..	..	..
4	.67	1.34	1.98	2.61	3.24	3.84	4.43	5.02	5.30	6.14	6.67	7.20	7.7	8.2	..	..	..	..	..	..
4⅛	.69	1.38	2.05	2.70	3.34	3.97	4.58	5.19	5.48	6.35	6.91	7.45	8.0	8.5	..	..	..	..	..	..
4¼	.71	1.42	2.11	2.78	3.45	4.10	4.73	5.36	5.66	6.57	7.14	7.71	8.3	8.8	..	..	..	..	..	..
4⅜	.74	1.46	2.17	2.87	3.56	4.23	4.88	5.53	5.84	6.78	7.37	7.96	8.5	9.1	..	..	..	..	..	..
4½	.76	1.51	2.24	2.95	3.66	4.35	5.03	5.70	6.02	6.99	7.61	8.22	8.8	9.4	10.0	..	..	..	..	..
4⅝	.78	1.55	2.30	3.04	3.77	4.48	5.18	5.87	6.20	7.20	7.84	8.47	9.1	9.7	10.3	..	..	..	..	..
4¾	.80	1.59	2.37	3.12	3.88	4.61	5.33	6.04	6.38	7.42	8.07	8.73	9.4	10.0	10.6	..	..	..	..	..
4⅞	.82	1.63	2.43	3.21	3.98	4.74	5.47	6.21	6.56	7.63	8.31	8.98	9.7	10.3	10.9	..	..	..	..	..
5	.84	1.68	2.49	3.29	4.09	4.86	5.62	6.38	6.74	7.84	8.54	9.24	9.9	10.6	11.3	11.9	..	..	..	..
5⅛	.86	1.72	2.56	3.38	4.19	4.99	5.77	6.55	6.92	8.05	8.78	9.49	10.2	10.9	11.6	12.2	..	..	..	.
5¼	.88	1.76	2.62	3.46	4.30	5.12	5.92	6.72	7.10	8.27	9.01	9.75	10.5	11.2	11.9	12.6	..	..	..	..
5⅜	.91	1.80	2.68	3.55	4.41	5.25	6.07	6.89	7.28	8.48	9.24	10.00	10.8	11.5	12.2	12.9	..	..	..	..
5½	.93	1.85	2.75	3.63	4.51	5.37	6.22	7.06	7.46	8.69	9.48	10.26	11.0	11.8	12.5	13.3	14.0	..	..	..
5⅝	.95	1.89	2.81	3.72	4.62	5.50	6.37	7.23	7.64	8.90	9.71	10.51	11.3	12.1	12.9	13.6	14.3	..	..	..
5¾	.97	1.93	2.88	3.80	4.73	5.63	6.52	7.40	7.82	9.12	9.94	10.77	11.6	12.4	13.2	13.9	14.7	..	..	..
5⅞	.99	1.97	2.94	3.89	4.83	5.76	6.66	7.57	8.01	9.33	10.18	11.02	11.9	12.7	13.5	14.3	15.1	..	..	..

Sum of Breadth of Flanges.	Thickness in Twentieths of an Inch.																			
	1/20	2/20	3/20	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
6	1.01	2.02	3.00	3.97	4.94	5.88	6.81	7.74	8.19	9.54	10.41	11.28	12.1	13.0	13.8	14.6	15.4	16.2	.	.
6⅛	1.03	2.06	3.07	4.06	5.04	6.01	6.96	7.91	8.37	9.75	10.65	11.53	12.4	13.3	14.1	15.0	15.8	16.6	.	.
6¼	1.05	2.10	3.13	4.14	5.15	6.14	7.11	8.08	8.55	9.97	10.88	11.79	12.7	13.6	14.5	15.3	16.2	17.0	.	..
6⅜	1.08	2.14	3.19	4.23	5.26	6.27	7.26	8.25	8.73	10.18	11.11	12.04	13.0	13.9	14.8	15.6	16.5	17.4	.	..
6½	1.10	2.19	3.26	4.31	5.36	6.39	7.41	8.42	8.91	10.39	11.35	12.30	13.2	14.2	15.1	16.0	16.9	17.8	18.6	..
6⅝	1.12	2.23	3.32	4.40	5.47	6.52	7.56	8.59	9.09	10.60	11.58	12.55	13.5	14.5	15.4	16.3	17.2	18.1	19.0	..
6¾	1.14	2.27	3.39	4.48	5.58	6.65	7.71	8.76	9.79	10.82	11.81	12.81	13.8	14.8	15.7	16.7	17.6	18.5	19.4	.
6⅞	1.16	2.31	3.45	4.57	5.68	6.78	7.85	8.93	9.98	11.03	12.05	13.06	14.1	15.1	16.0	17.0	18.0	18.9	19.8	..
7	1.18	2.36	3.51	4.65	5.79	6.90	8.00	9.10	10.17	11.24	12.28	13.32	14.3	15.4	16.4	17.3	18.3	19.3	20.2	21.2
7⅛	1.20	2.40	3.58	4.74	5.89	7.03	8.15	9.27	10.36	11.45	12.52	13.57	14.6	15.7	16.7	17.7	18.7	19.7	20.6	21.6
7¼	1.22	2.44	3.64	4.82	6.00	7.16	8.30	9.44	10.55	11.67	12.75	13.83	14.9	16.0	17.0	18.0	19.0	20.0	21.0	22.0
7⅜	1.25	2.48	3.70	4.91	6.11	7.29	8.45	9.61	10.75	11.88	12.98	14.08	15.2	16.3	17.3	18.4	19.4	20.4	21.4	22.4
7½	1.27	2.53	3.77	4.99	6.21	7.41	8.60	9.78	10.94	12.09	13.22	14.34	15.5	16.5	17.6	18.7	19.8	20.8	21.8	22.9
7⅝	1.29	2.57	3.83	5.08	6.32	7.54	8.75	9.95	11.13	12.30	13.45	14.59	15.7	16.8	18.0	19.0	20.1	21.2	22.2	23.3
7¾	1.31	2.61	3.90	5.16	6.43	7.67	8.90	10.12	11.32	12.52	13.68	14.85	16.0	17.1	18.3	19.4	20.5	21.6	22.6	23.7
7⅞	1.33	2.65	3.96	5.25	6.53	7.80	9.04	10.29	11.51	12.73	13.92	15.10	16.3	17.4	18.6	19.7	20.7	22.0	23.1	24.1
8	1.35	2.70	4.02	5.33	6.64	7.92	9.19	10.46	11.70	12.94	14.15	15.36	16.6	17.7	18.9	20.1	21.2	22.3	23.5	24.6
8⅛		2.74	4.09	5.42	6.74	8.05	9.34	10.63	11.89	13.15	14.39	15.61	16.8	18.0	19.2	20.4	21.6	22.7	23.9	25.0
8¼		2.78	4.15	5.50	6.85	8.18	9.49	10.80	12.08	13.37	14.62	15.87	17.1	18.3	19.6	20.7	21.9	23.1	24.3	25.4
8⅜		2.82	4.21	5.59	6.96	8.31	9.64	10.97	12.28	13.58	14.85	16.12	17.4	18.6	19.9	21.1	22.3	23.5	24.7	25.8
8½	.	2.87	4.28	5.67	7.06	8.43	9.79	11.14	12.47	13.79	15.09	16.38	17.7	18.9	20.2	21.4	22.7	23.9	25.1	26.3
8⅝		2.91	4.34	5.70	7.17	8.56	9.94	11.31	12.66	14.00	15.32	16.63	17.9	19.2	20.5	21.8	23.0	24.3	25.5	26.7
8¾	.	2.95	4.41	5.84	7.28	8.69	10.09	11.48	12.85	14.22	15.55	16.89	18.2	19.5	20.8	22.1	23.4	24.6	25.9	27.7
8⅞	..	2.99	4.47	5.93	7.38	8.82	10.23	11.65	13.04	14.43	15.79	17.14	18.5	19.8	21.1	22.4	23.7	25.0	26.3	27.5

Sum of Breadth of Flanges.	Thickness in Twentieths of an Inch.																			
	$\frac{1}{20}$	$\frac{2}{20}$	$\frac{3}{20}$	$\frac{4}{20}$	$\frac{5}{20}$	$\frac{6}{20}$	$\frac{7}{20}$	$\frac{8}{20}$	$\frac{9}{20}$	$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{13}{20}$	$\frac{14}{20}$	$\frac{15}{20}$	$\frac{16}{20}$	$\frac{17}{20}$	$\frac{18}{20}$	$\frac{19}{20}$	$\frac{20}{20}$
9		3.04	4.53	6.01	7.49	8.94	10.38	11.82	13.23	14.64	16.02	17.40	18.8	20.1	21.5	22.8	24.1	25.4	26.7	28.0
9⅛			4.60	6.10	7.59	9.07	10.53	11.99	13.42	14.85	16.26	17.65	19.0	20.4	21.8	23.1	24.5	25.8	27.1	28.4
9¼			4.66	6.18	7.70	9.20	10.68	12.16	13.61	15.07	16.49	17.91	19.3	20.7	22.1	23.5	24.8	26.2	27.5	28.8
9⅜			4.72	6.27	7.81	9.33	10.83	12.23	13.81	15.28	16.72	18.16	19.6	21.0	22.4	23.8	25.2	26.5	27.9	29.2
9½			4.79	6.35	7.91	9.45	10.98	12.50	14.00	15.49	16.96	18.42	19.9	21.3	22.7	24.1	25.5	26.9	28.3	29.7
9⅝			4.85	6.44	8.02	9.58	11.13	12.67	14.19	15.70	17.19	18.67	20.1	21.6	23.1	24.5	25.9	27.3	28.7	30.1
9¾			4.92	6.52	8.13	9.71	11.28	12.84	14.38	15.92	17.24	18.93	20.4	21.9	23.4	24.8	26.3	27.7	29.1	30.5
9⅞			4.98	6.61	8.23	9.84	11.42	13.01	14.57	16.13	17.66	19.18	20.7	22.2	23.7	25.2	26.6	28.1	29.5	30.9
10			5.04	6.69	8.34	9.96	11.57	13.18	14.76	16.34	17.89	19.44	21.0	22.5	24.0	25.5	27.0	28.5	29.9	31.4
10⅛				6.78	8.44	10.09	11.72	13.35	14.95	16.55	18.13	19.69	21.3	22.8	24.3	25.8	27.3	28.8	30.3	31.8
10¼				6.86	8.55	10.22	11.87	13.52	15.14	16.77	18.36	19.95	21.5	23.1	24.7	26.2	27.7	29.2	30.7	32.2
10⅜				6.95	8.66	10.35	12.02	13.69	15.34	16.98	18.59	20.20	21.8	23.4	25.0	26.5	28.1	29.6	31.1	32.6
10½				7.03	8.76	10.47	12.17	13.86	15.53	17.19	18.83	20.46	22.1	23.7	25.3	26.9	28.4	30.0	31.5	33.1
10⅝				7.12	8.87	10.60	12.32	14.03	15.72	17.40	19.06	20.71	22.4	24.0	25.6	27.2	28.8	30.4	31.9	33.5
10¾				7.20	8.98	10.73	12.47	14.20	15.91	17.62	19.29	20.97	22.6	24.3	25.9	27.5	29.2	30.8	32.3	33.9
10⅞				7.29	9.08	10.86	12.61	14.37	16.10	17.83	19.53	21.22	22.9	24.6	26.2	27.9	29.5	31.1	32.7	34.3
11				7.37	9.19	10.98	12.76	14.54	16.29	18.04	19.76	21.48	23.2	24.9	26.2	28.2	29.9	31.5	33.1	34.8
11⅛					9.29	11.11	12.91	14.71	16.48	18.25	20.00	21.73	23.5	25.2	26.9	28.6	30.2	31.9	33.6	35.2
11¼					9.40	11.24	13.06	14.88	16.67	18.47	20.23	21.99	23.7	25.5	27.2	28.9	30.6	32.3	34.0	35.6
11⅜					9.51	11.37	13.21	15.05	16.87	18.68	20.46	22.24	24.0	25.8	27.5	29.2	31.0	32.7	34.4	36.0
11½					9.61	11.49	13.36	15.22	17.06	18.89	20.70	22.50	24.3	26.1	27.8	29.6	31.3	33.1	34.8	36.5
11⅝					9.72	11.62	13.51	15.39	17.25	19.10	20.93	22.75	24.6	26.4	28.2	29.9	31.7	33.4	35.2	36.9
11¾					9.83	11.75	13.66	15.56	17.44	19.32	21.16	23.01	24.8	26.7	28.5	30.3	32.0	33.8	35.6	37.3
11⅞					9.93	11.88	13.80	15.73	17.63	19.53	21.40	23.26	25.1	27.0	28.8	30.6	32.4	34.2	36.0	37.7

Sum of Breadth of Flanges	Thickness in Twentieths of an Inch.																			
	$\frac{1}{20}$	$\frac{2}{20}$	$\frac{3}{20}$	$\frac{4}{20}$	$\frac{5}{20}$	$\frac{6}{20}$	$\frac{7}{20}$	$\frac{8}{20}$	$\frac{9}{20}$	$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{13}{20}$	$\frac{14}{20}$	$\frac{15}{20}$	$\frac{16}{20}$	$\frac{17}{20}$	$\frac{18}{20}$	$\frac{19}{20}$	$\frac{20}{20}$
12					10.04	12.00	13.95	15.90	17.82	19.74	21.63	23.52	25.4	27.3	29.1	30.9	32.8	34.6	36.4	38.2
$12\frac{1}{8}$						12.13	14.10	16.07	18.01	19.95	21.87	23.77	25.7	27.6	29.4	31.3	33.1	35.0	36.8	38.6
$12\frac{1}{4}$						12.26	14.25	16.24	18.20	20.17	22.10	24.03	26.0	27.9	29.8	31.6	33.5	36.3	37.2	39.0
$12\frac{3}{8}$						12.39	14.40	16.41	18.40	20.38	22.33	24.28	26.2	28.2	30.1	32.0	33.9	35.7	37.6	39.4
$12\frac{1}{2}$						12.51	14.55	16.58	18.59	20.59	22.57	24.54	26.5	28.4	30.4	32.3	34.2	36.1	38.0	39.9
$12\frac{5}{8}$						12.64	14.70	16.75	18.78	20.80	22.80	24.79	26.8	28.7	30.7	32.6	34.6	36.5	38.4	40.3
$12\frac{3}{4}$						12.77	14.85	16.92	18.97	21.02	23.03	25.05	27.1	29.0	31.0	33.0	34.9	36.9	38.8	40.7
$12\frac{7}{8}$						12.90	14.99	17.09	19.16	21.23	23.27	25.30	27.3	29.3	31.3	33.3	35.3	37.3	39.2	41.1
13						13.02	15.14	17.26	19.35	21.44	23.50	25.56	27.6	29.6	31.7	33.7	35.7	37.6	39.6	41.6
$13\frac{1}{8}$							15.29	17.43	19.54	21.65	23.74	25.81	27.9	29.9	32.0	34.0	36.0	38.0	40.0	42.0
$13\frac{1}{4}$							15.44	17.60	19.73	21.87	23.97	26.07	28.2	30.2	32.3	34.3	36.4	38.4	40.4	42.4
$13\frac{3}{8}$							15.59	17.77	19.93	22.08	24.20	26.32	28.4	30.5	32.6	34.7	36.7	38.8	40.8	42.8
$13\frac{1}{2}$							15.74	17.94	20.12	22.29	24.44	26.58	28.7	30.8	32.9	35.0	37.1	39.2	41.2	43.3
$13\frac{5}{8}$							15.89	18.11	20.31	22.50	24.67	26.83	29.0	31.1	33.3	35.4	37.5	39.6	41.6	43.7
$13\frac{3}{4}$							16.04	18.28	20.50	22.72	24.90	27.09	29.3	31.4	33.6	35.7	37.8	39.9	42.0	44.1
$13\frac{7}{8}$							16.18	18.45	20.69	22.93	25.14	27.34	29.5	31.7	34.0	36.0	38.2	40.3	42.4	44.5
14							16.33	18.62	20.88	23.14	25.37	27.60	29.8	32.0	34.2	36.4	38.5	40.7	42.8	45.0
$14\frac{1}{8}$								18.79	21.07	23.35	25.61	27.85	30.1	32.3	34.5	36.7	38.9	41.3	43.2	45.4
$14\frac{1}{4}$								18.96	21.26	23.57	25.84	28.11	30.4	32.6	34.9	37.1	39.3	41.5	43.6	45.8
$14\frac{3}{8}$								19.13	21.46	23.78	26.07	28.36	30.6	32.9	35.2	37.4	39.6	41.8	44.0	46.2
$14\frac{1}{2}$								19.30	21.65	23.99	26.31	28.62	30.9	33.2	35.5	37.7	40.0	42.2	44.5	46.7
$14\frac{5}{8}$								19.47	21.84	24.20	26.54	28.87	31.2	33.5	35.8	38.1	40.4	42.6	44.9	47.1
$14\frac{3}{4}$								19.64	22.03	24.42	26.77	29.13	31.5	33.8	36.1	38.4	40.7	43.0	45.3	47.5
$14\frac{7}{8}$								19.81	22.22	24.63	27.01	29.38	31.8	34.1	36.4	38.8	41.1	43.4	45.7	47.9
15								19.98	23.41	24.84	27.24	29.94	32.0	34.4	36.8	39.1	41.4	43.8	46.1	48.4

STEEL SHIPBUILDING SECTIONS.—ZEE BAR.

Weight in Pounds per Foot Run.

Sum of Breadth of Flanges and Web	Thickness in Twentieths of an Inch. 1/20	2/20	3/20	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
2	.32	.61	.87	1.09	...					...	...	...	...	...	...	...	...	...	...	...
2¼	.37	.70	.99	1.26	...					...	...	...	...	...	...	...	...	...	...	...
2½	.41	.78	1.12	1.43						...	...	...	...	...	...	...	...	...	...	...
2¾	.45	.87	1.25	1.60						...	...	...	...	...	...	...	...	...	...	...
3	.49	.95	1.38	1.77	2.18					...	...	...	...	...	...	...	...	...	...	...
3¼	.54	1.04	1.50	1.94	2.34					...	...	...	...	...	...	...	...	...	...	...
3½	.58	1.12	1.63	2.11	2.55	2.96				...	...	...	...	...	...	...	...	...	...	...
3¾	.62	1.21	1.76	2.28	2.76	3.21				...	...	...	...	...	...	...	...	...	...	...
4	.66	1.29	1.89	2.45	2.98	3.47				...	...	...	...	...	...	...	...	...	...	...
4¼		1.38	2.01	2.62	3.19	3.72				...	...	...	...	...	...	...	...	...	...	...
4½		1.46	2.14	2.79	3.40	3.98	4.52			...	...	...	...	...	...	...	...	...	...	...
4¾		1.55	2.27	2.96	3.61	4.23	4.82			...	...	...	...	...	...	...	...	...	...	...
5	...	1.63	2.40	3.13	3.83	4.49	5.12			...	...	...	...	...	...	...	...	...	...	...
5¼		1.72	2.52	3.30	4.04	4.74	5.41			...	...	...	...	...	...	...	...	...	...	...
5½		1.80	2.65	3.47	4.25	5.00	5.71	6.39		...	...	...	...	...	...	...	...	...	...	...
5¾		1.89	2.78	3.64	4.46	5.25	6.01	6.73	...	...	...	...	...	...	...	...	...	...	...	...
6	...	1.97	2.91	3.81	4.86	5.51	6.31	7.07	7.80	...	...	...	...	...	...	...	...	...	...	...
6¼			3.03	3.98	4.89	5.76	6.60	7.41	8.19	...	...	...	...	...	...	...	...	...	...	...
6½	...	...	3.16	4.15	5.10	6.02	6.90	7.75	8.57	...	...	...	...	...	...	...	...	...	...	...
6¾			3.29	4.32	5.31	6.27	7.20	8.09	8.95	...	...	...	...	...	...	...	...	...	...	...

Sum of Breadth of Flanges and Web.	Thickness in Twentieths of an Inch.																			
	1/20	2/20	3/20	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
7			3.42	4.49	5.53	6.53	7.50	8.43	9.33	10.20										
7¼			3.54	4.66	5.74	6.78	7.79	8.77	9.72	10.63										
7½			3.67	4.83	5.95	7.04	8.09	9.11	10.10	11.05	11.97									
7¾			3.80	5.00	6.16	7.29	8.39	9.45	10.48	11.48	12.44									
8			3.93	5.17	6.38	7.55	8.69	9.79	10.86	11.90	12.90									
8¼				5.34	6.59	7.80	8.98	10.13	11.25	12.33	12.37									
8½				5.51	6.80	8.06	9.28	10.47	11.63	12.75	13.84	14.89								
8¾				5.68	7.01	8.31	9.58	10.81	12.01	13.18	14.31	15.40								
9				5.85	7.23	8.57	9.88	11.15	12.39	13.60	14.77	15.91								
9¼				6.02	7.44	8.82	10.17	11.49	12.78	14.03	15.24	16.42								
9½				6.19	7.65	9.08	10.47	11.83	13.16	14.45	15.71	16.93	18.12							
9¾				6.36	7.86	9.33	10.77	12.17	13.54	14.88	16.18	17.44	18.67							
10				6.53	8.08	9.59	11.07	12.51	13.92	15.30	16.64	17.95	19.23	20.47						
10¼				6.70	8.29	9.84	11.36	12.85	14.31	15.73	17.11	18.46	19.78	21.06						
10½				6.87	8.50	10.10	11.66	13.19	14.69	16.15	17.58	18.97	20.33	21.66						
10¾				7.04	8.71	10.35	11.96	13.53	15.07	16.58	18.05	19.48	20.88	22.55						
11				7.21	8.93	10.61	12.26	13.87	15.45	17.00	18.51	19.99	21.44	22.85	24.23					
11¼				7.38	9.14	10.86	12.55	14.21	15.84	17.43	18.98	20.50	21.99	23.44	24.86					
11½				7.55	9.35	11.12	12.85	14.55	16.22	17.85	19.45	21.01	22.54	24.06	25.50	26.93				
11¾				7.72	9.56	11.37	13.15	14.89	16.60	18.28	19.92	21.52	23.09	24.63	26.14	27.61				

Sum of Breadth of Flanges and Web.	Thickness in Twentieths of an Inch.																			
	1/20	2/20	3/20	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
12				7.89	9.78	11.63	13.45	15.23	16.98	18.70	20.38	22.03	23.65	25.23	26.78	28.29		...	.	.
12¼					9.99	11.88	13.74	15.57	17.37	19.13	20.85	22.54	24.20	25.82	27.41	28.97		.	..	.
12½					10.20	12.14	14.04	15.91	17.75	19.55	21.32	23.05	24.75	26.42	28.05	29.65	31.21	.		
12¾					10.41	12.39	14.34	16.25	18.13	19.98	21.79	23.56	25.30	27.01	28.69	30.33	31.93			..
13					10.63	12.65	14.64	16.59	18.51	20.40	22.25	24.07	25.86	27.61	29.33	31.01	32.66			.
13¼					10.84	12.90	14.93	16.93	18.90	20.83	22.72	24.58	26.41	28.20	29.96	31.69	33.38		.	..
13½					11.05	13.16	15.23	17.27	19.28	21.25	23.19	25.09	26.96	28.80	30.60	32.37	34.10	35.80	.	..
13¾					11.26	13.41	15.53	17.61	19.66	21.68	23.66	25.60	27.51	29.39	31.24	33.05	34.82	36.57	..	...
14					11.48	13.67	15.83	17.95	20.04	22.10	24.12	26.11	28.07	29.99	31.88	33.73	35.55	37.33	39.06	.
14¼					11.69	13.92	16.12	18.29	20.43	22.53	24.59	26.62	28.62	30.58	32.51	34.41	36.27	38.10	39.89	
14½					11.90	14.18	16.42	18.63	20.81	22.95	25.06	27.13	29.17	31.18	33.15	35.09	36.99	38.86	40.70	..
14¾					12.11	14.43	16.72	18.97	21.19	23.38	25.53	27.64	29.72	31.77	33.79	35.77	37.71	39.63	41.51	..
15					12.33	14.69	17.02	19.31	21.57	23.80	25.99	28.15	30.28	32.37	34.43	36.45	38.44	40.39	42.31	44.20
15¼					12.54	14.94	17.31	19.65	21.96	24.23	26.46	28.66	30.83	32.96	35.06	37.13	39.16	41.16	43.12	45.05
15½					12.75	15.20	17.61	19.99	22.34	24.65	26.93	29.17	31.38	33.56	35.70	37.80	39.88	41.92	44.93	45.90
15¾					12.96	15.45	17.91	20.33	22.72	25.08	27.40	29.68	31.93	34.15	36.34	38.49	40.60	42.69	44.74	46.75
16					13.18	15.71	18.21	20.67	23.10	25.50	27.88	30.19	32.49	34.75	36.98	39.17	41.33	43.45	45.54	47.60
16¼					..	15.96	18.50	21.01	23.49	25.93	28.33	30.70	33.04	35.34	37.61	39.85	42.05	44.22	46.35	48.45
16½					.	16.22	18.80	21.35	23.87	26.35	28.80	31.21	33.59	35.94	38.25	40.53	42.77	44.98	47.16	49.30
16¾					.	16.47	19.10	21.69	24.25	26.78	29.27	31.72	34.14	36.53	38.89	41.21	43.49	45.75	47.97	50.15

Sum of Breadth of Flanges and Web.	Thickness in Twentieths of an Inch.																			
	1/20	2/20	3/20	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
17						16.73	19.40	22.03	24.63	27.20	29.73	32.23	34.70	37.13	39.53	41.89	44.22	46.51	48.77	51.00
17¼						16.98	19.69	22.37	25.02	27.63	30.20	32.74	35.25	37.72	40.16	42.57	44.94	47.28	49.58	51.85
17½						17.24	19.99	22.71	25.40	28.05	30.67	33.25	35.80	38.32	40.80	43.25	45.66	48.04	50.39	52.70
17¾						17.49	20.29	23.05	25.78	28.48	31.14	33.76	36.35	38.91	41.44	43.93	46.38	48.81	51.20	53.55
18						16.3	20.59	23.39	26.16	28.90	31.60	34.27	36.91	39.51	42.08	44.61	47.11	49.57	52.00	54.40
18¼							20.88	23.73	26.55	29.33	32.07	34.78	37.46	40.10	42.71	45.29	47.83	50.34	52.81	55.25
18½							21.18	24.07	26.93	29.75	32.54	35.29	38.01	40.70	43.35	45.97	48.55	51.10	53.62	56.10
18¾							21.48	24.41	27.31	30.18	33.01	35.80	38.56	41.29	43.99	46.65	49.27	51.87	54.43	56.95
19							21.78	24.75	27.69	30.60	33.47	36.31	39.12	41.89	44.63	47.33	50.00	52.63	55.23	57.80
19¼							22.07	25.09	28.08	31.03	33.94	36.82	39.67	42.48	45.26	48.01	50.72	53.40	56.04	58.65
19½							22.37	25.43	28.46	31.45	34.41	37.33	40.22	43.08	45.90	48.69	51.44	54.16	56.85	59.50
19¾							22.67	25.77	28.84	31.88	34.88	37.84	40.77	43.67	46.54	49.37	52.16	54.93	57.66	60.35
20							22.97	26.11	29.22	32.30	35.34	38.35	41.33	44.27	47.18	50.05	52.89	55.69	58.46	61.20
20¼							23.26	26.45	29.61	32.73	35.81	38.86	41.88	44.86	47.81	50.73	53.61	56.46	59.27	62.05
20½							23.56	26.79	29.99	33.15	36.28	39.37	42.43	45.46	48.45	51.41	54.33	57.22	60.08	62.90
20¾							23.86	27.13	30.37	33.58	36.75	39.88	42.98	46.05	49.09	52.09	55.05	57.99	60.89	63.75
21							24.16	27.47	30.75	34.00	37.21	40.39	43.54	46.65	49.73	52.77	55.78	58.75	61.69	64.60
21¼							24.45	27.81	31.14	34.43	37.68	40.90	44.09	47.24	50.36	53.45	56.50	59.52	62.50	65.45
20½							24.75	28.15	31.52	34.85	38.15	41.41	44.64	47.84	51.00	54.13	57.22	60.28	63.31	66.30
20¾							25.05	28.49	31.90	35.28	38.62	41.92	45.19	48.43	51.64	54.81	57.94	61.05	64.12	67.15

Sum of Breadth of Flanges and Web	Thickness in Twentieths of an Inch. 1/20	2/20	3/20	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
22							25.35	28.83	32.28	35.70	39.08	42.43	45.75	49.03	52.28	55.49	58.67	61.81	64.92	68.00
22¼							25.64	29.17	32.67	36.13	39.55	42.94	46.30	49.62	52.91	56.17	59.39	62.58	65.73	68.85
22½							25.94	29.51	33.05	36.55	40.02	43.45	46.85	50.22	53.55	56.85	60.11	63.34	66.54	69.70
22¾							26.24	29.85	33.43	36.98	40.49	43.96	47.40	50.81	54.19	57.53	60.83	64.11	67.35	70.55
23							26.54	30.19	33.81	37.40	40.95	44.47	47.96	51.41	54.83	58.21	61.56	64.87	68.15	71.40
23¼							26.83	30.53	34.20	37.83	41.42	44.98	48.51	52.00	55.46	58.89	62.28	65.64	68.96	72.25
23½							27.13	30.87	34.58	38.25	41.89	45.40	49.06	52.60	56.10	59.57	63.00	66.40	69.77	73.10
23¾							27.43	31.21	34.96	38.68	42.36	46.00	49.61	53.19	56.74	60.25	63.72	67.17	70.58	73.95
24							27.73	31.55	35.34	39.10	42.82	46.51	50.17	53.79	57.38	60.93	64.45	67.93	71.38	74.80
24¼							.	31.89	35.73	39.53	43.29	47.02	50.72	54.38	38.01	61.61	65.17	68.70	72.19	75.65
24½							...	32.23	36.11	39.95	43.76	47.53	51.27	54.98	58.65	62.29	05.89	69.46	73.00	76.50
24¾							...	32.57	36.49	40.38	44.23	48.04	51.82	55.57	59.29	62.97	66.61	70.23	73.81	77.35
25							...	32.91	36.87	40.80	44.69	48.55	52.38	56.17	59.93	63.65	67.34	70.99	74.61	78.20
25¼								33.25	37.26	41.23	45.16	49.06	52.93	56.76	60.56	64.33	68.06	71.76	75.42	79.05
25½							.	33.59	37.64	41.65	45.63	49.57	53.48	57.36	61.20	65.01	68.78	72.52	76.23	79.90
25¾							...	33.93	38.02	42.08	46.10	50.08	54.03	57.95	61.84	65.69	69.50	73.29	77.04	80.75
26							..	34.27	38.40	42.50	46.56	50.59	54.59	58.55	62.48	66.37	70.23	74.05	77.84	81.60
26¼							..	34.61	38.79	42.93	47.03	51.10	55.14	59.14	63.11	67.05	70.95	74.82	78.65	82.45
26½							...	34.95	39.17	43.35	47.50	51.61	55.69	59.74	63.75	67.73	71.67	75.58	79.46	83.30
26¾							.	35.29	39.55	43.78	47.97	52.12	56.24	60.33	64.39	68.41	72.39	76.35	80.27	84.15

STEEL SHIPBUILDING SECTIONS. — CHANNEL.

Weight in Pounds per Foot Run.

Sum of Web and Flanges. (Ins.)	Thickness in Twentieths of an Inch.																			
	1/20	2/20	3/20	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
2	.32	.61	.87	1 09																
2⅛	.34	65	93	1 17																
2¼	.37	70	99	1.26																
2⅜	39	74	1.06	1.34																
2½	41	78	1 12	1 43																
2⅝	43	.82	1 19	1.51																
2¾	45	.87	1.25	1.60																
2⅞	47	91	1 31	1.68																
3	49	95	1.38	1 77	2.13															
3⅛	.51	.99	1.44	1.85	2.23															
3¼	54	1 04	1.50	1 94	2 34															
3⅜	.56	1.08	1.57	2.02	2.44															
3½	.58	1 12	1.63	2.11	2.55	2 96														
3⅝	.60	1 16	1 70	2.19	2 68	3 09														
3¾	.62	1.21	1.76	2.28	2.76	3.21														
3⅞	.64	1.25	1.82	2.36	2.87	3.34														

Sum of Web and Flanges. (Ins.)	Thickness in Twentieths of an Inch. 1/20	2/20	3/20	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	16/20	16/20	17/20	18/20	19/20	20/20
4	.66	1.29	1.89	2.45	2.98	3.47														
4⅛		1.33	1.95	2.53	3.08	3.60														
4¼		1.38	2.01	2.62	3.19	3.72														
4⅜		1.42	2.08	2.70	3.29	3.85														
4½		1.46	2.14	2.79	3.40	3.98	4.52													
4⅝		1.50	2.21	2.87	3.51	4.11	4.67													
4¾		1.55	2.27	2.96	3.61	4.23	4.82													
4⅞		1.59	2.33	3.04	3.72	4.36	4.97													
5		1.63	2.40	3.13	3.83	4.49	5.12													
5⅛		1.67	2.45	3.21	3.93	4.62	5.27													
5¼		1.72	2.52	3.30	4.04	4.74	5.41													
5⅜		1.76	2.59	3.38	4.14	4.87	5.56													
5½		1.80	2.65	3.47	4.25	5.00	5.71	6.39												
5⅝		1.84	2.72	3.55	4.36	5.13	5.86	6.56												
5¾		1.89	2.78	3.64	4.46	5.25	6.01	6.73												
5⅞		1.93	2.84	3.72	4.57	5.38	6.16	6.90												
6		1.97	2.91	3.81	4.68	5.51	6.31	7.07	7.80											
6⅛			2.97	3.89	4.78	5.64	6.46	7.24	7.99											
6¼			3.03	3.98	4.89	5.76	6.60	7.41	8.19											
6⅜			3.10	4.06	4.99	5.89	6.75	7.58	8.38											
6½			3.16	4.15	5.10	6.02	6.90	7.75	8.57											
6⅝			3.23	4.23	5.21	6.15	7.05	7.92	8.76											
6¾			3.29	4.32	5.31	6.27	7.20	8.09	8.95											
6⅞			3.35	4.40	5.42	6.40	7.35	8.26	9.14											

Sum of Web and Flanges. (Ins.)	Thickness in Twentieths of an Inch. 1/20	2/20	3/20	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
7			3.42	4.49	5.53	6.53	7.50	8.43	9.33	10.20										
7⅛			3.48	4.57	5.63	6.66	7.65	8.60	9.52	10.41										
7¼			3.54	4.66	5.74	6.78	7.79	8.77	9.72	10.63										
7⅜			3.61	4.74	5.84	6.91	7.94	8.94	9.91	10.84										
7½			3.67	4.83	5.95	7.04	8.09	9.11	10.10	11.05	11.97									
7⅝			3.74	4.91	6.06	7.17	8.24	9.28	10.29	11.26	12.20									
7¾			3.80	5.00	6.16	7.29	8.39	9.45	10.48	11.48	12.44									
7⅞			3.86	5.08	6.27	7.42	8.54	9.62	10.67	11.69	12.67									
8			3.93	5.17	6.38	7.55	8.69	9.79	10.86	11.90	12.90									
8⅛				5.25	6.48	7.68	8.84	9.96	11.05	12.11	13.14									
8¼				5.34	6.59	7.80	8.98	10.13	11.25	12.33	13.37									
8⅜				5.42	6.69	7.93	9.13	10.30	11.44	12.54	13.60									
8½				5.51	6.80	8.06	9.28	10.47	11.63	12.75	13.84	14.89								
8⅝				5.59	6.91	8.19	9.43	10.64	11.82	12.96	14.07	15.15								
8¾				5.68	7.01	8.31	9.58	10.81	12.01	13.18	14.31	15.40								
8⅞				5.76	7.12	8.44	9.73	10.98	12.20	13.39	14.54	15.66								
9				5.85	7.23	8.57	9.88	11.15	12.39	13.60	14.77	15.91								
9⅛				5.93	7.33	8.70	10.03	11.32	12.58	13.81	15.01	16.17								
9¼				6.02	7.44	8.82	10.17	11.49	12.78	14.03	15.24	16.42								
9⅜				6.10	7.54	8.95	10.32	11.66	12.96	14.24	15.47	16.68								
9½				6.19	7.65	9.08	10.47	11.83	13.16	14.45	15.71	16.93	18.12							
9⅝				6.27	7.76	9.21	10.62	12.00	13.35	14.66	15.94	17.19	18.40							
9¾				6.36	7.86	9.33	10.77	12.17	13.54	14.88	16.18	17.44	18.67							
9⅞				6.44	7.97	9.46	10.92	12.34	13.73	15.09	16.41	17.70	18.95							

Sum of Web and Flanges. (Ins.)	Thickness in Twentieths of an Inch. 1/20	2/20	3/20	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
10				6.53	8.08	9.59	11.07	12.51	13.92	15.30	16.64	17.95	19.23	20.47						
10⅛				6.61	8.18	9.72	11.22	12.68	14.11	15.51	16.88	18.21	19.50	20.77						
10¼				6.70	8.29	9.84	11.36	12.85	14.31	15.73	17.11	18.46	19.78	21.06						
10⅜				6.78	8.39	9.97	11.51	13.02	14.50	15.94	17.34	18.72	20.06	21.36						
10½				6.87	8.50	10.10	11.66	13.19	14.69	16.15	17.58	18.97	20.33	21.66						
10⅝				6.95	8.61	10.23	11.81	13.36	14.88	16.36	17.81	19.23	20.61	21.96						
10¾				7.04	8.71	10.35	11.96	13.53	15.07	16.58	18.05	19.48	20.88	22.25						
10⅞				7.12	8.82	10.48	12.11	13.70	15.26	16.79	18.28	19.74	21.16	22.55						
11				7.21	8.93	10.61	12.26	13.87	15.45	17.00	18.51	19.99	21.44	22.85	24.23					
11⅛				7.29	9.03	10.74	12.41	14.04	15.64	17.21	18.75	20.25	21.71	23.15	24.54					
11¼				7.38	9.14	10.86	12.55	14.21	15.84	17.43	18.98	20.50	21.99	23.64	24.86					
11⅜				7.46	9.24	10.99	12.70	14.38	16.03	17.64	19.21	20.76	22.27	23.76	25.18					
11½				7.55	9.35	11.12	12.85	14.55	16.22	17.85	19.45	21.01	22.54	24.06	25.50	26.93				
11⅝				7.63	9.46	11.25	13.00	14.72	16.41	18.06	19.68	21.27	22.82	24.34	25.82	27.27				
11¾				7.72	9.56	11.37	13.15	14.89	16.60	18.28	19.92	21.52	23.09	24.63	26.14	27.61				
11⅞				7.80	9.67	11.50	13.30	15.06	16.79	18.49	20.15	21.78	23.37	24.93	26.46	27.95				
12				7.89	9.78	11.63	13.45	15.23	16.98	18.70	20.38	22.03	23.65	25.23	26.78	28.29				
12⅛					9.88	11.76	13.60	15.40	17.17	18.91	20.62	22.29	23.92	25.53	27.09	28.63				
12¼					9.99	11.88	13.74	15.57	17.37	19.13	20.85	22.54	24.20	25.82	27.41	28.97				
12⅜					10.09	12.01	13.89	15.74	17.50	19.34	21.08	22.80	24.48	26.12	27.73	29.31				
12½					10.20	12.14	14.04	15.91	17.75	19.55	21.32	23.05	24.75	26.42	28.05	29.65	31.21			
12⅝					10.31	12.27	14.19	16.08	17.94	19.76	21.55	23.31	25.03	26.72	28.37	29.99	31.57			
12¾					10.41	12.39	14.34	16.25	18.13	19.98	21.79	23.56	25.30	27.01	28.69	30.33	31.93			
12⅞					10.52	12.52	14.49	16.42	18.32	20.19	22.02	23.82	25.58	27.31	29.01	30.67	32.30			

Sum of Web and Flanges. (Ins.)	1/20	2/20	3/20	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
	Thickness in Twentieths of an Inch.																			
13					10.63	12.65	14.64	16.59	18.51	20.40	22.25	24.07	25.86	27.61	29.33	31.01	32.66	. . .	. . .	. . .
13⅛					10.73	12.78	14.79	16.76	18.70	20.61	22.49	24.33	26.13	27.91	29.64	31.35	33.02	. . .	. . .	. . .
13¼					10.84	12.90	14.93	16.93	18.90	20.83	22.72	24.58	26.41	28.90	29.96	31.69	33.38		. . .	. . .
13⅜					10.94	13.03	15.08	17.10	19.09	21.04	22.95	24.84	26.69	28.50	30.28	32.03	33.74			
13½					11.05	13.16	15.23	17.27	19.28	21.25	23.19	25.09	26.96	28.80	30.60	32.37	34.10	35.80	. .	
13⅝					11.16	13.29	15.38	17.44	19.47	21.46	23.42	25.35	27.24	29.10	30.92	32.71	34.46	36.18	.	
13¾					11.26	13.41	15.53	17.61	19.66	21.68	23.66	25.60	27.51	29.39	31.24	33.05	34.82	36.57	. .	
13⅞					11.37	13.54	15.68	17.78	19.85	21.89	23.89	25.86	27.79	29.69	31.56	33.39	35.19	36.95		
14					11.48	13.67	15.83	17.95	20.04	22.10	24.12	26.11	28.07	29.99	31.88	33.73	35.55	37.33	39.08	
14⅛					11.58	13.80	15.98	18.12	20.23	22.31	24.36	26.37	28.34	30.29	32.19	34.07	35.91	37.71	39.49	
14¼					11.69	13.92	16.12	18.29	20.43	22.53	24.59	20.62	28.62	30.58	32.51	34.41	36.27	38.10	38.89	
14⅜					11.79	14.05	16.27	18.46	20.62	22.74	24.82	26.88	28.90	30.88	32.83	34.75	36.63	38.48	40.29	
14½					11.90	14.18	16.42	18.63	20.81	22.95	25.06	27.13	29.17	31.18	33.15	35.09	36.99	38.86	40.70	
14⅝					12.01	14.31	16.57	18.80	21.00	23.16	25.29	27.39	29.45	31.48	33.47	35.43	37.35	39.24	41.10	
14¾					12.11	14.43	16.72	18.97	21.19	23.38	25.53	27.64	29.72	31.77	33.79	35.77	37.71	39.63	41.51	
14⅞					12.22	14.56	16.87	19.14	21.38	23.59	25.76	27.90	30.00	32.07	34.11	36.11	38.08	40.01	41.91	
15					12.33	14.69	17.02	19.31	21.57	23.80	25.99	28.15	30.28	32.37	34.43	36.45	38.44	40.39	42.31	44.20
15⅛					12.43	14.82	17.17	19.48	21.76	24.01	26.23	28.41	30.55	32.67	34.74	36.79	38.80	40.77	42.72	44.63
15¼					12.54	14.94	17.31	19.65	21.96	24.23	26.46	28.66	30.83	32.96	35.06	37.13	39.16	41.16	43.12	45.05
15⅜					12.64	15.07	17.46	19.82	22.15	24.44	26.69	28.92	31.11	32.26	35.38	37.47	39.52	41.54	43.52	45.08
15½					12.75	15.20	17.61	19.99	22.34	24.65	26.93	29.17	31.38	33.56	35.70	37.80	39.88	41.92	43.93	45.90
15⅝					12.86	15.33	17.76	20.16	22.53	24.86	27.16	29.43	31.66	33.86	36.02	38.15	40.24	42.30	44.33	46.33
15¾					12.96	15.45	17.91	20.33	22.72	25.08	27.40	29.68	31.93	34.15	36.34	38.49	40.60	42.69	44.74	46.75
15⅞					13.07	15.58	18.05	20.50	22.91	25.29	27.63	29.94	32.21	34.45	36.66	38.83	40.97	43.07	45.14	47.18

Sum of Web and Flanges. (Ins.)	Thickness in Twentieths of an Inch.																			
	$\frac{1}{20}$	$\frac{2}{20}$	$\frac{3}{20}$	$\frac{4}{20}$	$\frac{5}{20}$	$\frac{6}{20}$	$\frac{7}{20}$	$\frac{8}{20}$	$\frac{9}{20}$	$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{13}{20}$	$\frac{14}{20}$	$\frac{15}{20}$	$\frac{16}{20}$	$\frac{17}{20}$	$\frac{18}{20}$	$\frac{19}{20}$	$\frac{20}{20}$
16					13.18	15.71	18.21	20.67	23.10	25.50	27.86	30.19	32.49	34.75	36.98	39.17	41.33	43.46	45.54	47.60
16⅛						15.84	18.36	20.84	23.29	25.71	28.10	30.45	32.76	35.05	37.29	39.51	41.69	43.83	45.95	48.03
16¼						15.96	18.50	21.01	23.49	25.93	28.33	30.70	33.04	35.34	37.61	39.85	42.05	44.22	46.35	48.46
16⅜						16.09	18.65	21.18	23.68	26.14	28.56	30.96	33.32	35.64	37.93	40.19	42.41	44.60	46.75	48.88
16½						16.22	18.80	21.35	23.87	26.35	28.80	31.21	33.59	35.94	38.25	40.53	42.77	44.98	47.16	49.30
16⅝						16.35	18.95	21.52	24.06	26.56	29.03	31.47	33.87	36.24	38.57	40.87	43.13	45.36	47.56	49.73
16¾						16.47	19.10	21.69	24.25	26.78	29.27	31.72	34.14	36.53	38.89	41.21	43.49	45.75	47.97	50.15
16⅞						16.60	19.25	[illegible]	24.44	26.99	29.50	31.98	34.42	36.83	39.21	41.55	43.86	46.13	48.37	50.58
17						16.73	19.40	22.03	24.63	27.20	29.73	32.23	34.70	37.13	39.53	41.89	44.22	46.51	48.77	51.00
17⅛						16.86	19.55	22.20	24.82	27.41	29.97	32.49	34.97	37.43	39.84	42.23	44.58	46.89	49.18	51.43
17¼						16.98	19.69	22.37	25.02	27.63	30.20	32.74	35.25	37.72	40.16	42.57	44.94	47.28	49.58	51.85
17⅜						17.11	19.84	22.54	25.21	27.84	30.43	33.00	35.53	38.02	40.48	42.91	45.30	47.66	49.98	52.28
17½						17.24	19.99	22.71	25.40	28.05	30.67	33.25	35.80	38.32	40.80	43.25	45.66	48.04	50.39	52.70
17⅝						17.37	20.14	22.88	25.59	28.26	30.90	33.51	36.08	38.62	41.12	43.59	46.02	48.42	50.79	53.13
17¾						17.49	20.29	23.05	25.78	28.48	31.14	33.76	36.35	38.91	41.44	43.93	46.38	48.81	51.20	53.55
17⅞						17.62	20.44	23.22	25.97	28.69	31.37	34.02	36.66	39.21	41.76	44.27	46.75	49.19	51.60	53.98
18						17.75	20.59	23.39	26.16	28.90	31.60	34.27	36.91	39.51	42.08	44.61	47.11	49.57	52.00	54.40
18⅛						17.88	20.74	23.56	26.35	29.11	31.84	34.53	37.18	39.81	42.39	44.95	47.47	49.95	52.41	54.83
18¼						18.00	20.88	23.73	26.55	29.33	32.07	34.78	37.46	40.10	42.71	45.29	47.83	50.34	52.81	55.25
18⅜						18.13	21.03	23.90	26.74	29.54	32.30	35.04	37.74	40.40	43.03	45.63	48.19	50.72	53.21	55.68
18½						18.26	21.18	24.07	26.93	29.75	32.54	35.29	38.01	40.70	43.35	45.97	48.55	51.10	53.62	56.10
18⅝						18.39	21.33	24.24	27.12	29.96	32.77	35.55	38.29	41.00	43.67	46.31	48.91	51.48	54.02	56.53
18¾						18.51	21.48	24.41	27.31	30.18	33.01	35.80	38.56	41.29	43.99	46.65	49.27	51.87	54.43	56.95
18⅞						18.64	21.63	24.58	27.50	30.39	33.24	36.06	38.84	41.59	44.31	46.99	49.64	52.25	54.83	57.38

Sum of Web and Flanges (Ins.)	Thickness in Twentieths of an Inch.																			
	1/20	2/20	3/20	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
19						18.77	21.78	24.75	27.69	30.60	33.47	36.31	39.12	41.89	44.63	47.33	50.00	52.63	55.23	57.80
19⅛						18.90	21.93	24.92	27.88	30.81	33.71	36.57	39.39	42.19	44.94	47.67	50.36	53.01	55.64	58.23
19¼						19.02	22.07	25.09	28.08	31.13	33.94	36.82	39.67	42.48	45.26	48.01	50.72	53.40	56.04	58.65
19⅜						19.15	22.22	25.26	28.27	31.24	34.17	37.08	39.95	42.78	45.58	48.35	51.08	53.78	56.44	59.08
19½						19.28	22.37	25.43	28.46	31.45	34.41	37.33	40.22	43.08	45.90	48.69	51.44	54.16	56.85	59.50
19⅝						19.41	22.52	25.60	28.65	31.66	34.64	37.59	40.50	43.38	46.22	49.03	51.80	54.54	57.25	59.93
19¾						19.53	22.67	25.77	28.84	31.88	34.88	37.84	40.77	43.67	46.54	49.37	52.16	54.93	57.66	60.35
19⅞						19.66	22.82	25.94	29.03	32.09	35.11	38.10	41.05	43.97	46.86	49.71	52.53	55.31	58.06	60.78
20						19.79	22.97	26.11	29.23	32.30	35.34	38.35	41.33	44.27	47.18	50.05	52.89	55.69	58.46	61.20
20⅛							23.12	26.28	29.41	32.51	35.58	38.61	41.60	44.57	47.49	50.39	52.25	56.07	58.87	61.63
20¼							23.26	26.45	29.61	32.73	35.81	38.86	41.88	44.86	47.81	50.73	53.61	56.46	59.27	62.05
20⅜							23.4[illegible]	26.62	20.80	32.94	36.04	39.12	42.16	45.16	48.13	51.07	53.97	56.84	59.67	62.48
20½							23.56	26.79	29.99	33.15	36.28	39.37	42.43	45.46	48.45	51.41	54.33	57.22	60.08	62.90
20⅝							23.71	26.96	30.18	33.36	36.51	39.63	42.71	45.76	48.77	51.75	54.69	57.60	60.48	63.33
20¾							23.86	27.13	30.3[illegible]	33.58	36.75	39.88	42.98	46.05	49.09	52.09	55.05	57.99	60.89	63.75
20⅞							24.01	27.30	30.56	33.79	36.98	40.14	43.26	46.35	49.41	52.43	55.42	58.37	61.29	64.18
21							24.16	27.47	30.75	34.00	37.21	40.39	43.54	46.65	49.73	52.77	55.78	58.75	61.69	64.60
21⅛							24.31	27.64	30.94	34.21	37.45	40.65	43.81	46.95	50.04	53.11	56.14	59.13	62.10	65.03
21¼							24.45	27.81	31.14	34.43	37.68	40.90	44.09	47.24	50.36	53.45	56.50	59.52	62.50	65.45
21⅜							24.60	27.98	31.33	34.64	37.91	41.16	44.37	47.54	50.68	53.79	56.86	59.90	62.90	65.88
21½							24.75	28.15	31.52	34.85	38.15	41.41	44.64	47.84	51.00	54.13	57.22	60.28	63.31	66.30
21⅝							24.90	28.32	31.71	35.06	38.38	41.67	44.92	48.14	51.32	54.47	57.58	60.66	63.71	66.73
21¾							25.05	28.49	31.90	35.28	38.62	41.92	45.19	48.43	51.64	54.81	57.94	61.05	64.12	67.15
21⅞							25.20	28.66	32.09	35.49	38.85	42.18	45.47	48.73	51.96	55.15	58.31	61.43	64.52	67.58

Sum of Web and Flanges. (Ins.)	$\frac{1}{20}$	$\frac{2}{20}$	$\frac{3}{20}$	$\frac{4}{20}$	$\frac{5}{20}$	$\frac{6}{20}$	$\frac{7}{20}$	$\frac{8}{20}$	$\frac{9}{20}$	$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{13}{20}$	$\frac{14}{20}$	$\frac{15}{20}$	$\frac{16}{20}$	$\frac{17}{20}$	$\frac{18}{20}$	$\frac{19}{20}$	$\frac{20}{20}$
	Thickness in Twentieths of an Inch																			
22							25.35	28.83	32.28	35.70	39.08	42.43	45.75	49.03	52.28	55.49	58.67	61.81	64.92	68.00
$22\frac{1}{8}$							25.50	29.00	32.47	35.91	39.32	42.69	46.02	49.33	52.59	55.83	59.03	62.19	65.33	68.43
$22\frac{1}{4}$							25.64	29.17	32.67	36.13	39.55	42.94	46.30	49.62	52.91	56.17	59.39	62.58	65.73	68.85
$22\frac{3}{8}$							25.79	29.34	32.86	36.34	39.78	43.20	46.58	49.92	53.23	56.51	59.75	62.96	66.13	69.28
$22\frac{1}{2}$							25.94	29.51	33.05	36.55	40.02	43.45	46.85	50.22	53.55	56.85	60.11	63.34	66.54	69.70
$22\frac{5}{8}$							26.09	29.68	33.24	36.76	40.25	43.71	47.13	50.52	53.87	57.19	60.47	63.72	66.94	70.13
$22\frac{3}{4}$							26.24	29.85	33.43	36.98	40.49	43.96	47.40	50.81	54.19	57.53	60.83	64.11	67.35	70.55
$22\frac{7}{8}$							26.39	30.02	33.62	37.19	40.72	44.22	47.68	51.11	54.51	57.87	61.20	64.49	67.75	70.98
23							26.54	30.19	33.81	37.40	40.95	44.47	47.96	51.41	54.83	58.21	61.56	64.87	68.15	71.40
$23\frac{1}{8}$							26.69	30.36	34.00	37.61	41.19	44.73	48.23	51.71	55.14	58.55	61.92	65.25	68.56	71.83
$23\frac{1}{4}$							26.83	30.53	34.20	37.83	41.42	44.98	48.51	52.00	55.46	58.89	62.28	65.64	68.96	72.25
$23\frac{3}{8}$							26.98	30.70	34.39	38.04	41.65	45.24	48.79	52.30	55.78	59.23	62.64	66.03	69.36	72.68
$23\frac{1}{2}$							27.13	30.87	34.58	38.25	41.89	45.49	49.06	52.60	56.10	59.57	63.00	66.40	69.77	73.10
$23\frac{5}{8}$							27.28	31.04	34.77	38.46	42.12	45.75	49.34	52.90	56.42	59.91	63.36	66.78	70.17	73.53
$23\frac{3}{4}$							27.43	31.21	34.96	38.68	42.36	46.00	49.61	53.19	56.74	60.25	63.72	67.17	70.58	73.95
$23\frac{7}{8}$							27.58	31.38	35.15	38.89	42.59	46.26	49.89	53.49	57.06	60.59	64.09	67.55	70.98	74.38
24							27.73	31.55	35.34	39.10	42.82	46.51	50.17	53.79	57.38	60.93	64.45	67.93	71.38	74.80
$24\frac{1}{8}$								31.72	35.53	39.31	43.06	46.77	50.44	54.09	57.69	61.27	64.81	68.31	71.79	75.23
$24\frac{1}{4}$								31.89	35.73	39.53	43.29	47.02	50.72	54.38	58.01	61.61	65.17	68.70	72.19	75.65
$24\frac{3}{8}$								32.06	35.92	39.74	43.52	47.28	51.00	54.68	58.33	61.95	65.53	69.08	72.59	76.08
$24\frac{1}{2}$								32.23	36.11	39.95	43.76	47.53	51.27	54.98	58.65	62.29	65.89	69.46	73.00	76.50
$24\frac{5}{8}$								32.40	36.30	40.16	43.99	47.79	51.55	55.28	58.97	62.63	66.25	69.84	73.40	76.93
$24\frac{3}{4}$								32.57	36.49	40.38	44.23	48.04	51.82	55.57	59.29	62.97	66.61	70.23	73.81	77.35
$24\frac{7}{8}$								32.74	36.48	40.59	44.46	48.30	52.10	55.87	59.61	63.31	66.98	70.61	74.21	77.78

Sum of Web and Flanges (Ins.)	Thickness in Twentieths of an Inch.																			
	$\frac{1}{20}$	$\frac{2}{20}$	$\frac{3}{20}$	$\frac{4}{20}$	$\frac{5}{20}$	$\frac{6}{20}$	$\frac{7}{20}$	$\frac{8}{20}$	$\frac{9}{20}$	$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{13}{20}$	$\frac{14}{20}$	$\frac{15}{20}$	$\frac{16}{20}$	$\frac{17}{20}$	$\frac{18}{20}$	$\frac{19}{20}$	$\frac{20}{20}$
25								32.91	36.87	40.80	44.69	48.55	52.38	56.17	59.93	63.65	67.34	70.99	74.61	78.20
$25\frac{1}{8}$								33.08	37.06	41.01	44.93	48.81	52.65	56.47	60.24	63.99	67.70	71.37	75.02	78.63
$25\frac{1}{4}$								33.25	37.26	41.23	45.16	49.06	52.93	56.76	60.56	64.33	68.06	71.76	75.42	79.05
$25\frac{3}{8}$								33.42	37.45	41.46	45.39	49.32	53.21	57.06	60.88	64.67	68.42	72.14	75.82	79.48
$25\frac{1}{2}$								33.59	37.64	41.65	45.63	49.57	53.48	57.36	61.20	65.01	68.78	72.52	76.23	79.90
$25\frac{5}{8}$								33.76	37.83	41.86	45.86	49.83	53.76	57.66	61.52	65.35	69.14	72.90	76.63	80.33
$25\frac{3}{4}$								33.93	38.02	42.08	46.10	50.08	54.03	57.95	61.84	65.69	69.50	73.29	77.04	80.75
$25\frac{7}{8}$								34.10	38.21	42.29	46.33	50.34	54.31	58.25	62.16	66.03	69.87	73.67	77.44	81.18
26								34.27	38.40	42.50	46.56	50.59	54.59	58.55	62.48	66.37	70.23	74.05	77.84	81.60
$26\frac{1}{8}$								34.44	38.59	42.71	46.80	50.85	54.86	58.85	62.79	66.71	70.59	74.43	78.25	82.03
$26\frac{1}{4}$								34.61	38.79	42.93	47.03	51.10	55.14	59.14	63.11	67.05	70.95	74.82	78.65	82.45
$26\frac{3}{8}$								34.78	38.98	43.14	47.26	51.36	55.42	59.46	63.43	67.39	71.31	75.20	79.05	82.88
$26\frac{1}{2}$								34.95	39.17	43.35	47.50	51.61	55.69	59.74	63.75	67.73	71.67	75.58	79.46	83.30
$26\frac{5}{8}$								35.12	39.36	43.56	47.73	51.87	55.97	60.04	64.07	68.07	72.03	75.96	79.86	83.73
$26\frac{3}{4}$								35.29	39.55	43.78	47.97	52.12	56.24	60.33	64.39	68.41	72.39	76.35	80.27	84.15
$26\frac{7}{8}$								35.40	39.74	43.99	48.20	52.38	56.52	60.63	64.71	68.75	72.76	76.73	80.67	84.58

Sum of Web and Flanges (Ins.)	Thickness in Twentieths of an Inch. 1/20	2/20	3/20	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
27								35.63	39.93	44.20	48.43	52.63	56.80	60.93	65.03	69.09	73.12	77.11	81.07	85.00
27⅛								35.80	40.12	44.41	48.67	52.89	57.07	61.23	65.34	69.43	73.48	77.49	81.48	85.43
27¼								35.97	40.32	44.63	48.90	53.14	57.35	61.52	65.66	69.77	73.84	77.88	81.88	85.85
27⅜								36.14	40.51	44.84	49.13	53.40	57.63	61.82	65.98	70.11	74.20	78.26	82.28	86.28
27½								36.31	40.70	45.05	49.37	53.65	57.90	62.12	66.30	70.45	74.56	78.64	82.69	86.70
27⅝								36.48	40.89	45.26	49.60	53.91	58.18	62.42	66.62	70.79	74.92	79.02	83.09	87.13
27¾								36.65	41.08	45.48	49.84	54.16	58.45	62.71	66.94	71.13	75.28	79.41	83.50	87.55
27⅞								36.82	41.27	45.69	50.07	54.42	58.73	63.01	67.26	71.47	76.65	79.79	83.90	87.98
28								36.99	41.46	45.90	50.30	54.67	59.01	63.31	67.58	71.81	76.01	80.17	84.30	88.40
28⅛									41.65	46.11	50.54	54.93	59.28	63.61	67.89	72.15	76.37	80.55	84.71	88.83
28¼									41.85	46.33	50.77	55.18	59.56	63.90	68.21	72.49	76.73	80.94	85.11	89.25
28⅜									42.04	46.54	51.00	55.44	59.84	64.20	68.53	72.83	77.09	81.32	85.51	89.68
28½									42.23	46.75	51.24	55.69	60.11	64.50	68.85	73.17	77.45	81.70	85.92	90.10
28⅝									42.42	46.96	51.47	55.95	60.39	64.80	69.17	73.51	77.81	82.08	86.32	90.53
28¾									42.61	47.18	51.71	56.20	60.66	65.09	69.40	73.85	78.17	82.47	86.73	90.95

STEEL SHIPBUILDING SECTIONS.—I SECTION.

Weight in Pounds per Foot Run.

Sum of Web and Tables.	Thickness in Twentieths of an Inch.																			
	1/20	2/20	3/20	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
6			3.06	4.08	5.10	6.12	7.14													
6¼			3.19	4.25	5.31	6.37	7.44	8.50												
6½			3.31	4.42	5.52	6.63	7.73	8.84												
6¾			3.44	4.59	5.74	6.88	8.03	9.18												
7			3.57	4.76	5.95	7.14	8.33	9.52												
7¼			3.69	4.93	6.16	7.39	8.63	9.86	10.09											
7½			3.81	5.10	6.37	7.65	8.92	10.20	11.47											
7¾			3.94	5.27	6.59	7.90	9.22	10.54	11.86											
8			4.07	5.44	6.80	8.16	9.52	10.88	12.24											
8¼			4.20	5.61	7.01	8.41	9.82	11.22	12.62	14.02										
8½			4.33	5.78	7.22	8.67	10.11	11.56	13.00	14.45										
8¾			4.46	5.95	7.44	8.92	10.41	11.90	13.39	14.87										
9			4.59	6.12	7.65	9.18	10.71	12.24	13.77	15.30										
9¼			4.72	6.29	7.86	9.43	11.01	12.58	14.15	15.72	17.3									
9½			4.84	6.46	8.07	9.69	11.30	12.92	14.53	16.15	17.8									
9¾			4.97	6.63	8.29	9.94	11.60	13.26	14.92	16.57	18.2									
10			5.10	6.80	8.50	10.20	11.90	13.60	15.30	17.00	18.7									
10¼			5.23	6.97	8.71	10.45	12.20	13.94	15.68	17.42	19.2	20.9								
10½			5.35	7.14	8.92	10.71	12.49	14.28	16.06	17.85	19.6	21.4								
10¾			5.48	7.31	9.14	10.96	12.79	14.62	16.45	18.27	20.1	21.9								

Sum of Web and Tables.	THICKNESS IN TWENTIETHS OF AN INCH.																			
	1/20	2/20	3/20	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
11			5.61	7.48	9.35	11.22	13.09	14.96	16.83	18.70	20.6	22.4								
11¼			5.74	7.65	9.56	11.47	13.39	15.30	17.21	19.12	21.0	22.9	24.9							
11½			5.86	7.82	9.77	11.73	13.68	15.64	17.59	19.55	21.5	23.5	25.4							
11¾			5.99	7.99	9.99	11.98	13.98	15.98	17.98	19.97	22.0	24.0	26.0							
12			6.12	8.16	10.20	12.24	14.28	16.32	18.36	20.40	22.4	24.5	26.5							
12¼			6.25	8.33	10.41	12.49	14.58	16.66	18.74	20.82	22.9	25.0	27.1	29.2						
12½			6.37	8.50	10.62	12.75	14.87	17.00	19.12	21.25	23.4	25.5	27.6	29.7						
12¾			6.50	8.67	10.84	13.00	15.17	17.34	19.51	21.67	23.8	26.0	28.2	30.3						
13			6.63	8.84	11.05	13.26	15.47	17.68	19.89	22.10	24.3	26.5	28.7	30.9						
13¼			6.76	9.01	11.26	13.51	15.77	18.02	20.27	22.52	24.8	27.0	29.3	31.5	33.8					
13½			6.88	9.18	11.47	13.77	16.06	18.36	20.65	22.95	25.2	27.5	29.8	32.1	34.4					
13¾			7.01	9.35	11.69	14.02	16.36	18.70	21.04	23.37	25.7	28.0	30.4	32.7	35.1					
14			7.14	9.52	11.90	14.28	16.66	19.04	21.42	23.80	26.2	28.6	30.9	33.3	35.7					
14¼			7.27	9.69	12.11	14.53	16.96	19.38	21.80	24.22	26.6	29.1	31.5	33.9	36.3	38.8				
14½				9.86	12.32	14.79	17.25	19.72	22.18	24.65	27.1	29.6	32.0	34.5	37.0	39.4				
14¾				10.03	12.54	15.04	17.55	20.06	22.57	25.07	27.6	30.1	32.6	35.1	37.6	40.1				
15				10.20	12.75	15.30	17.85	20.40	22.95	25.50	28.0	30.6	33.1	35.7	38.3	40.8				
15¼				10.37	12.96	15.55	18.15	20.74	23.33	25.92	28.5	31.1	33.7	36.3	38.9	41.5	44.1			
15½				10.54	13.17	15.81	18.44	21.08	23.71	26.35	29.0	31.6	34.3	36.9	39.5	42.2	44.8			
15¾				10.71	13.39	16.06	18.74	21.42	24.10	26.77	29.5	32.1	34.8	37.5	40.2	42.8	45.5			

Sum of Web and Tables.	Thickness in Twentieths of an Inch.																			
	1/20	2/20	3/20	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
16				10.88	13.60	16.32	19.04	21.76	24.48	27.20	29.9	32.6	35.4	38.1	40.8	43.5	46.2			...
16¼				11.05	13.81	16.57	19.34	22.10	24.86	27.62	30.4	33.1	35.9	38.7	41.4	44.2	47.0	49.7		...
16½				11.22	14.02	16.83	19.63	22.44	25.24	28.05	30.9	33.7	36.5	39.3	42.1	44.9	47.7	50.5	..	..
16¾				11.39	14.24	17.08	19.93	22.78	25.63	28.47	31.3	34.2	37.0	39.9	42.7	45.6	48.4	51.3	...	...
17						17.34	20.23	23.12	26.01	28.90	31.8	34.7	37.6	40.5	43.4	46.2	49.1	52.0		..
17¼						17.59	20.53	23.46	26.39	29.32	32.3	35.2	38.1	41.1	44.0	46.9	49.9	52.8	55.7	...
17½					...	17.85	20.83	23.80	26.77	29.75	32.7	35.7	38.7	41.6	44.6	47.6	50.6	53.5	56.5	
17¾					...	18.10	21.12	24.14	27.16	30.17	33.2	36.2	39.2	42.2	45.3	48.3	51.3	54.3	57.3	
18					...	18.36	21.42	24.48	27.54	30.60	33.7	36.7	39.8	42.8	49.9	49.0	52.0	55.1	58.1	
18¼					..	18.61	21.72	24.82	27.92	31.02	34.1	37.2	40.3	43.4	46.5	49.6	52.7	55.8	58.9	62.1
18½					..	18.87	22.01	25.16	28.30	31.45	34.6	37.7	40.9	44.0	47.2	50.3	53.5	56.6	59.8	62.9
18¾					..	19.12	22.31	25.50	28.69	31.87	35.1	38.2	41.4	44.6	47.8	51.0	54.2	57.4	60.6	63.8
19					16.15	19.38	22.61	25.84	29.07	32.30	35.5	38.8	42.0	45.2	48.4	51.7	54.9	58.1	61.4	64.6
19¼						19.63	22.91	26.18	29.45	32.72	36.0	39.3	42.5	45.8	49.1	52.4	55.6	58.9	62.2	65.4
19½						19.89	23.20	26.52	29.83	33.15	36.5	39.8	43.1	46.4	49.7	53.0	56.4	59.7	63.0	66.3
19¾						20.14	23.50	26.86	30.22	33.57	36.9	40.3	43.6	47.0	50.4	53.7	57.1	60.4	63.8	67.1
20				..	..	20.40	23.80	27.20	30.60	34.00	37.4	40.8	44.2	47.6	51.0	54.4	57.8	61.2	64.6	68.0
20¼			..		...	20.65	24.10	27.54	30.98	34.42	37.9	41.3	44.8	48.2	51.6	55.1	58.5	62.0	65.4	68.8
20½		..		..	..	20.91	24.39	27.88	31.30	34.85	38.3	41.8	45.3	48.8	52.3	55.8	59.2	62.7	66.2	69.7
20¾		..		...	..	21.16	24.69	28.22	31.75	35.27	38.8	42.3	45.9	49.4	52.9	56.4	60.0	63.5	67.0	70.5

Sum of Web and Tables.	$\frac{1}{20}$	$\frac{2}{20}$	$\frac{3}{20}$	$\frac{4}{20}$	$\frac{5}{20}$	$\frac{6}{20}$	$\frac{7}{20}$	$\frac{8}{20}$	$\frac{9}{20}$	$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{13}{20}$	$\frac{14}{20}$	$\frac{15}{20}$	$\frac{16}{20}$	$\frac{17}{20}$	$\frac{18}{20}$	$\frac{19}{20}$	$\frac{20}{20}$
	Thickness in Twentieths of an Inch																			
21						21.42	24.09	28.56	32.13	35.70	39.3	42.8	46.4	50.0	53.5	57.1	60.7	64.3	67.8	71.4
21¼						21.67	25.29	28.90	32.51	36.12	39.7	43.3	47.0	50.6	54.2	57.8	61.4	65.0	68.6	72.2
21½						21.93	25.58	29.24	32.89	36.55	40.2	43.9	47.5	51.2	54.8	58.5	62.1	65.8	69.4	73.1
21¾						22.18	25.88	29.58	33.25	36.97	40.7	44.4	48.1	51.8	55.5	59.2	62.9	66.6	70.3	74.0
22							26.18	29.92	33.66	37.40	41.1	44.9	48.6	52.4	56.1	59.8	63.6	67.3	71.1	74.8
22¼							26.48	30.26	34.04	37.82	41.6	45.4	49.2	53.0	56.7	60.5	64.3	68.1	71.9	75.6
22½							26.77	30.60	34.42	38.25	42.1	45.9	49.7	53.5	57.4	61.2	65.0	68.8	72.7	76.5
22¾							27.07	30.96	34.81	38.67	42.5	46.4	50.3	54.1	58.0	61.9	65.7	69.6	73.5	77.3
23							27.37	31.28	35.19	39.10	43.0	46.9	50.8	54.7	58.6	62.6	66.5	70.4	74.3	78.2
23¼							27.67	31.62	35.57	39.52	43.5	47.4	51.4	55.3	59.3	63.2	67.2	71.1	75.1	79.0
23½							27.96	31.96	35.95	39.95	43.9	47.9	51.9	55.9	59.9	63.9	67.9	71.9	75.9	79.9
23¾							28.26	32.30	36.34	40.37	44.4	48.4	52.5	56.5	60.6	64.6	68.6	72.7	76.7	80.7
24							28.56	32.64	36.72	40.80	44.9	49.0	53.0	57.1	61.2	65.3	69.4	73.4	77.5	81.6
24¼							28.86	32.98	37.10	41.22	45.3	49.5	53.6	57.7	61.8	66.0	70.1	74.2	78.3	82.4
24½								33.32	37.48	41.65	45.8	50.0	54.1	58.3	62.5	66.6	70.8	75.0	79.1	83.3
24¾								33.66	37.87	42.07	46.3	50.5	54.7	58.9	63.1	67.3	71.5	75.7	79.9	84.1
25								34.00	38.25	42.50	46.7	51.0	55.2	59.5	63.7	68.0	72.2	76.5	80.7	85.0
25¼								34.34	38.63	42.92	47.2	51.5	55.8	60.1	64.4	68.7	73.0	77.3	81.6	85.8
25½								34.68	39.01	43.35	47.7	52.0	56.4	60.7	65.0	69.4	73.7	78.0	82.4	86.7
25¾								35.02	39.40	43.77	48.2	52.5	56.9	61.3	65.7	70.0	74.4	78.8	83.2	87.6

Sum of Web and Tables.	Thickness in Twentieths of an Inch.																			
	$\frac{1}{20}$	$\frac{2}{20}$	$\frac{3}{20}$	$\frac{4}{20}$	$\frac{5}{20}$	$\frac{6}{20}$	$\frac{7}{20}$	$\frac{8}{20}$	$\frac{9}{20}$	$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{13}{20}$	$\frac{14}{20}$	$\frac{15}{20}$	$\frac{16}{20}$	$\frac{17}{20}$	$\frac{18}{20}$	$\frac{19}{20}$	$\frac{20}{20}$
26								35.36	39.78	44.20	48.6	53.0	57.5	61.9	66.3	70.7	75.1	79.6	84.0	88.4
26¼								35.70	40.16	44.62	49.1	53.5	58.0	62.5	66.9	71.4	75.9	80.3	84.8	89.2
26½								36.04	40.54	45.05	49.6	54.1	58.6	63.1	67.6	72.1	76.6	81.1	85.6	0.1
26¾								36.38	40.93	45.47	50.0	54.6	59.1	63.7	68.2	72.8	77.3	81.9	86.4	90.9
27									41.31	45.40	50.5	55.1	59.7	64.3	68.8	73.4	78.0	82.6	87.2	91.8
27¼									41.69	46.32	51.0	55.6	60.2	64.9	69.5	74.1	78.8	83.4	88.0	92.6
27½									42.07	46.75	51.4	56.1	60.8	65.4	70.1	74.8	79.5	84.1	88.8	93.5
27¾									42.46	47.17	51.9	56.6	61.3	66.0	70.8	75.5	80.2	84.9	89.6	94.3
28									42.84	47.60	52.4	57.1	61.9	66.6	71.4	76.2	80.9	85.7	90.4	95.2
28¼									43.22	48.02	52.8	57.6	62.4	67.2	72.0	76.8	81.6	86.4	91.2	96.0
28½									43.60	48.45	53.3	58.1	63.0	67.8	72.7	77.5	82.4	87.2	92.1	96.9
28¾									43.99	48.87	53.8	58.6	63.5	68.4	73.3	78.2	83.1	88.0	92.9	97.7
29									44.37	49.30	54.2	59.2	64.1	69.0	73.9	78.9	83.8	88.7	93.7	98.6
29¼									44.76	49.72	54.7	59.7	64.6	69.6	74.6	79.6	84.5	89.5	94.5	99.4
29½										50.15	55.2	60.2	65.2	70.2	75.2	80.2	85.3	90.3	95.3	100.3
29¾										50.57	55.6	60.7	65.7	70.8	75.9	80.9	86.0	91.0	96.1	101.1
30										51.00	56.1	61.2	66.3	71.4	76.5	81.6	86.7	91.8	96.9	102.0
30¼										51.42	56.6	61.7	66.9	72.0	77.1	82.3	87.4	92.6	97.7	102.8
30½										51.85	57.0	62.2	67.4	72.6	77.8	83.0	88.1	93.3	98.5	103.7
30¾										52.27	57.5	62.7	68.0	73.2	78.4	83.6	88.9	94.1	99.3	104.5

Sum of Web and Tables	Thickness in Twentieths of an Inch. $\frac{1}{20}$	$\frac{2}{20}$	$\frac{3}{20}$	$\frac{4}{20}$	$\frac{5}{20}$	$\frac{6}{20}$	$\frac{7}{20}$	$\frac{8}{20}$	$\frac{9}{20}$	$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{13}{20}$	$\frac{14}{20}$	$\frac{15}{20}$	$\frac{16}{20}$	$\frac{17}{20}$	$\frac{18}{20}$	$\frac{19}{20}$	$\frac{20}{20}$
31										52.70	58.0	63.2	68.5	73.8	79.0	84.3	89.0	94.9	100.1	105.4
31¼											58.4	63.7	69.1	74.4	79.7	85.0	90.3	95.6	100.9	106.2
31½										..	58.9	64.3	69.6	75.0	80.3	85.7	91.0	96.4	101.7	107.1
31¾										...	59.4	64.8	70.2	75.6	81.0	86.4	91.8	97.2	102.6	107.9
32											59.8	65.3	70.7	76.2	81.6	87.0	92.5	97.9	103.4	108.8
32¼											60.3	65.8	71.3	76.8	82.2	87.7	93.2	98.7	104.2	109.6
32½											60.8	66.3	71.8	77.3	82.9	88.4	93.9	99.4	105.0	110.5
32¾											61.2	66.8	72.4	77.9	83.5	89.1	94.6	100.2	105.8	111.3
33											61.7	67.3	72.9	78.5	84.1	89.8	95.4	101.0	106.6	112.2
33¼											62.2	67.8	73.5	79.1	84.8	90.4	96.1	101.7	107.4	113.0
33½											62.6	68.3	74.0	79.7	85.4	91.1	96.8	102.5	108.2	113.9
33¾											63.1	68.8	74.6	80.3	86.1	91.8	97.5	103.3	109.0	114.7
34											63.6	69.4	75.1	80.9	86.7	92.5	98.3	104.0	109.8	115.6
34¼											64.0	69.9	75.7	81.5	87.3	93.2	99.0	104.8	110.6	116.4
34½												70.4	76.2	82.1	88.0	93.8	99.7	105.6	111.4	117.3
34¾												70.9	76.8	82.7	88.6	94.5	100.4	106.3	112.2	118.1
35												71.4	77.3	83.3	89.2	95.2	101.1	107.1	113.0	119.0
35¼												71.9	77.9	83.9	89.9	95.9	101.9	107.9	113.9	119.8
35½												72.4	78.5	84.5	90.5	96.6	102.6	108.6	114.7	120.7
35¾												72.9	79.0	85.1	91.2	97.2	103.3	109.4	115.5	121.5

STEEL.—ROUND AND SQUARE BARS.

Sectional Area in Inches × 3.4 = Weight per Lineal Foot in Pounds.

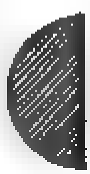
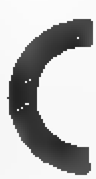
Thickness or Diameter in Inches.	Weight per Lineal Foot in Pounds. Round. ○	Square. □	Area of ● in Sq. Ins.	Thickness or Diameter in Inches.	Weight per Lineal Foot in Pounds. Round. ○	Square. □	Area of ● in Sq. Ins.
0	....	....	....	2	10.68	13.60	3 1416
1/16	.010	.013	.0031	1/16	11.36	14 46	3 3410
1/8	.042	.053	.0123	1/8	12.06	15 35	3.5466
3/16	.094	.119	.0276	3/16	12.78	16.27	3.7583
1/4	.167	212	.0491	1/4	13.51	17.22	3 9761
5/16	.261	.332	.0767	5/16	14 28	18.19	4 2000
3/8	.375	.478	.1104	3/8	15.06	19.18	4.4301
7/16	.511	.651	.1503	7/16	15.86	20.20	4.6664
1/2	.667	.850	.1963	1/2	16 69	21.25	4 9087
9/16	.844	1.076	.2485	9/16	17.53	22 33	5 1572
5/8	1.043	1.328	.3068	5/8	18.40	23 43	5 4119
11/16	1.261	1.607	.3712	11/16	19.29	24.56	5 6727
3/4	1.502	1 912	.4418	3/4	20 20	25 71	5 9396
13/16	1.762	2 245	.5185	13/16	21.12	26.90	0.2126
7/8	2.044	2.603	.6013	7/8	22.07	28 10	6.4918
15/16	2.347	2.989	.6903	15/16	23.04	29 33	6 7771
1	2.670	3 400	.7854	3	24 01	30 60	7 0686
1/16	3 014	3 838	.8866	1/16	25.04	31.88	7.3662
1/8	3.379	4 303	.9940	1/8	26.08	33.20	7 6699
3/16	3.766	4.795	1.1075	3/16	27 13	34.55	7 9798
1/4	4.173	5 312	1 2272	1/4	28 20	35.91	8 2958
5/16	4.600	5.857	1 3530	5/16	29 30	37.31	8 6179
3/8	5.049	6.428	1.4849	3/8	30.41	38.73	8 9462
7/16	5 518	7.026	1 6230	7/16	31.55	40.18	9 2806
1/2	6.008	7 650	1.7671	1/2	32.71	41.65	9.6211
9/16	6.520	8 301	1.9175	9/16	33 89	43.15	9 9678
5/8	7.051	8 978	2.0739	5/8	35 09	44 68	10 321
11/16	7.604	9 682	2.2365	11/16	36 31	46.24	10.680
3/4	8.178	10 41	2 4053	3/4	37 55	47.82	11 045
13/16	8.773	11.17	2.5802	13/16	38.81	49.42	11 416
7/8	9 388	11.95	2 7612	7/8	40 10	51 06	11 793
15/16	10.024	12.76	2.9483	15/16	41.40	52.71	12.177

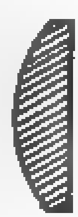
STEEL.—ROUND AND SQUARE BARS.

Sectional Area in Inches × 3.4 = Weight per Lineal Foot in Pounds.

Thickness or Diameter in Inches.	Weight per Lineal Foot in Pounds. Round. ○	Square. □	Area of ● in Sq. Ins.	Thickness or Diameter in Inches.	Weight per Lineal Foot in Pounds. Round. ○	Square. □	Area of ● in Sq. Ins.
4	42.72	54.39	12.566	6	96.1	122.4	28.274
$\frac{1}{16}$	44.07	56.11	12.962	$\frac{1}{16}$	98.1	125.0	28.866
$\frac{1}{8}$	45.44	57.85	13.364	$\frac{1}{8}$	100.2	127.6	29.465
$\frac{3}{16}$	46.83	59.62	13.772	$\frac{3}{16}$	102.2	130.2	30.069
$\frac{1}{4}$	48.23	61.41	14.186	$\frac{1}{4}$	104.3	132.8	30.680
$\frac{5}{16}$	49.66	63.23	14.607	$\frac{5}{16}$	106.4	135.5	31.296
$\frac{3}{8}$	51.11	65.08	15.033	$\frac{3}{8}$	108.5	138.2	31.919
$\frac{7}{16}$	52.58	66.95	15.466	$\frac{7}{16}$	110.7	140.9	32.548
$\frac{1}{2}$	54.07	68.85	15.904	$\frac{1}{2}$	112.8	143.6	33.183
$\frac{9}{16}$	55.59	70.78	16.349	$\frac{9}{16}$	115.0	146.5	33.824
$\frac{5}{8}$	57.12	72.72	16.800	$\frac{5}{8}$	117.2	149.2	34.472
$\frac{11}{16}$	58.67	74.70	17.257	$\frac{11}{16}$	119.4	152.1	35.125
$\frac{3}{4}$	60.25	76.71	17.721	$\frac{3}{4}$	121.7	154.9	35.785
$\frac{13}{16}$	61.84	78.74	18.190	$\frac{13}{16}$	123.9	157.8	36.450
$\frac{7}{8}$	63.46	80.80	18.665	$\frac{7}{8}$	126.2	160.7	37.122
$\frac{15}{16}$	65.10	82.89	19.147	$\frac{15}{16}$	128.5	163.6	37.800
5	66.76	85.00	19.635	7	130.9	166.6	38.485
$\frac{1}{16}$	68.44	87.14	20.129	$\frac{1}{16}$	133.2	169.6	39.175
$\frac{1}{8}$	70.13	89.30	20.629	$\frac{1}{8}$	135.6	172.6	39.871
$\frac{3}{16}$	71.86	91.49	21.135	$\frac{3}{16}$	137.9	175.6	40.574
$\frac{1}{4}$	73.60	93.72	21.648	$\frac{1}{4}$	140.4	178.7	41.282
$\frac{5}{16}$	75.37	95.96	22.166	$\frac{5}{16}$	142.8	181.8	41.997
$\frac{3}{8}$	77.15	98.22	22.691	$\frac{3}{8}$	145.2	184.9	42.718
$\frac{7}{16}$	78.95	100.5	23.221	$\frac{7}{16}$	147.7	188.1	43.445
$\frac{1}{2}$	80.77	102.8	23.758	$\frac{1}{2}$	150.2	191.3	44.179
$\frac{9}{16}$	82.62	105.2	24.301	$\frac{9}{16}$	152.7	194.4	44.918
$\frac{5}{8}$	84.48	107.6	24.850	$\frac{5}{8}$	155.2	197.7	45.664
$\frac{11}{16}$	86.38	110.0	25.406	$\frac{11}{16}$	157.8	200.9	46.415
$\frac{3}{4}$	88.29	112.4	25.967	$\frac{3}{4}$	160.3	204.2	47.173
$\frac{13}{16}$	90.22	114.9	26.535	$\frac{13}{16}$	163.0	207.6	47.937
$\frac{7}{8}$	92.16	117.4	27.109	$\frac{7}{8}$	165.6	210.8	48.707
$\frac{15}{16}$	94.14	119.9	27.688	$\frac{15}{16}$	168.2	214.2	49.483

WEIGHTS. — Half-Round, Hollow Half-Round, Feather Edge, and Convex.

Description.	Size. Breadth.	Size. Thickness.	Weight per Lineal Foot.
Half-Round. 	6	3	48.07
	5½	2¾	40.39
	5	2½	33.38
	4½	2¼	27.04
	4	2	21.36
	3¾	1⅞	18.78
	3½	1¾	16.36
	3¼	1⅝	14.11
	3	1½	12.02
	2¾	1⅜	10.10
	2½	1¼	8.34
	2¼	1⅛	6.75
	2	1	5.34
	1¾	⅞	4.09
	1½	¾	3.00
	1¼	⅝	2.09
	1	½	1.34
Hollow Half-Round. 	4	1¼	18.36
	3¾	1⅛	15.78
	3½	1	13.36
	3½	9/16	8.83
	3½	½	8.01
	3¼	½	7.35
	3	½	6.68
	2½	½	5.34
	2	⅜	3.26
	1½	⅜	2.25
Feather Edge. 	2½	⅝	3.73
	2½	½	2.98
	2¼	½	2.69
	2	½	2.39
	2	7/16	2.09
	2	⅜	1.79
	1¾	⅜	1.57
	1½	⅜	1.34
	1⅜	⅜	1.23
	1¼	5/16	.93
	1⅛	5/16	.85

Description.	Size. Breadth.	Size. Thickness.	Weight per Lineal Foot.
Convex (Square at Edge). 	2½	1	7.17
	2½	15/16	6.64
	2½	⅞	6.11
	2½	13/16	5.58
	2½	¾	5.05
	2½	11/16	4.52
	2½	⅝	3.98
	2	¾	4.30
	2	⅝	3.45
	2	9/16	3.03
	2	½	2.60
	1¾	¾	3.76
	1¾	⅝	3.02
	1¾	9/16	2.65
	1¾	½	2.28
	1½	¾	3.25
	1½	⅝	2.62
	1½	9/16	2.30
	1½	½	1.98
	1⅜	¾	2.99
	1⅜	11/16	2.70
	1⅜	⅝	2.41
	1⅜	9/16	2.12
	1⅜	½	1.82
	1¼	½	1.72
	1¼	7/16	1.46
	1¼	⅜	1.19
	1⅛	½	1.56
	1⅛	7/16	1.32
	1	⅜	1.09

WEIGHT OF SHEET STEEL.

No. of Gauge.	Birmingham Wire Gauge and English Standard Gauge.		American (B. & S.) Wire Gauge.		New U.S. Standard Gauge, 1873.	
	Thickness in Inches.	Weight per Sq. Ft.	Thickness in Inches.	Weight per Sq. Ft.	Thickness in Inches.	Weight per Sq. Ft.
0000	.454	18.52	.460	18.76	.406	16.58
000	.425	17.34	.410	16.72	.375	15.30
00	.380	15.50	.365	14.88	.344	14.03
0	.340	13.87	.325	13.26	.313	12.75
1	.300	12.24	.289	11.80	.281	11.48
2	.284	11.59	.258	10.52	.266	10.84
3	.259	10.56	.229	9.36	.250	10.20
4	.238	9.71	.204	8.33	.234	9.56
5	.220	8.98	.182	7.42	.219	8.93
6	.203	8.28	.162	6.61	.203	8.29
7	.180	7.34	.144	5.88	.188	7.65
8	.165	6.73	.129	5.24	.172	7.01
9	.148	6.04	.114	4.66	.156	6.38
10	.134	5.47	.102	4.15	.141	5.74
11	.120	4.89	.091	3.70	.125	5.10
12	.109	4.44	.081	3.29	.109	4.46
13	.095	3.87	.072	2.93	.094	3.83
14	.083	3.38	.064	2.61	.078	3.19
15	.072	2.94	.057	2.32	.070	2.87
16	.065	2.65	.051	2.07	.063	2.55
17	.058	2.37	.045	1.84	.056	2.30
18	.049	1.99	.040	1.64	.050	2.04
19	.042	1.71	.036	1.46	.044	1.79
20	.035	1.42	.032	1.30	.038	1.53
21	.032	1.30	.028	1.16	.034	1.40
22	.028	1.14	.025	1.03	.031	1.28
23	.025	1.02	.023	0.921	.028	1.15
24	.022	0.898	.020	0.821	.025	1.02
25	.020	0.816	.018	0.729	.022	0.89
26	.018	0.734	.016	0.651	.019	0.77
27	.016	0.653	.014	0.581	.017	0.70
28	.014	0.571	.013	0.515	.016	0.64
29	.013	0.531	.011	0.459	.014	0.57
30	.012	0.489	.010	0.409	.013	0.51
31	.010	0.408	.009	0.364	.011	0.45
32	.009	0.367	.008	0.324	.010	0.41
33	.008	0.326	.007	0.288	.009	0.38
34	.007	0.286	.006	0.257	.009	0.35
35	.005	0.204	.006	0.228	.008	0.32
36	*.004*	*0.162*	.005	0.204	.007	0.29

STEEL SHIPBUILDING SECTIONS.—BULB-ANGLE.

Weight in Pounds per Foot Run.

Web.	Flange.	Thickness in Twentieths of an Inch.																
		4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
2	1	2.47	2.91	3.32	3.72	4.11												
"	1¼	2.64	3.12	3.58	4.02	4.45												
"	1½	2.81	3.33	3.83	4.32	4.79	5.24											
"	1¾	2.98	3.55	4.09	4.62	5.13	5.62											
2¼	1	2.68	3.16	3.62	4.06	4.49												
"	1¼	2.85	3.37	3.87	4.36	4.83												
"	1½	3.02	3.59	4.13	4.66	5.17	5.66											
"	1¾	3.19	3.80	4.38	4.95	5.51	6.04											
2½	1¼	3.10	3.67	4.21	4.74	5.25	5.74											
"	1½	3.27	3.88	4.46	5.03	5.59	6.12											
"	1¾	3.44	4.09	4.72	5.33	5.93	6.50	7.07										
"	2	3.61	4.30	4.97	5.63	6.27	6.89	7.49										
2¾	1¼	3.33	3.94	4.52	5.09	5.65	6.18											
"	1½	3.50	4.15	4.78	5.39	5.99	6.56											
"	1¾	3.67	4.36	5.03	5.69	6.33	6.95	7.55										
"	2	3.84	4.58	5.29	5.99	6.67	7.33	7.98										
3	1½	3.73	4.42	5.09	5.75	6.39	7.01	7.61										
"	1¾	3.90	4.64	5.35	6.05	6.73	7.39	8.04										
"	2	4.07	4.85	5.60	6.34	7.07	7.77	8.46	9.13									
"	2¼	4.24	5.06	5.86	6.64	7.41	8.15	8.89	9.60									

Web.	Flange.	Thickness in Twentieths of an Inch.																
		4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
3¼	1½	3.98	4.72	5.43	6.13	6.81	7.47	8.1	...	...	...	...	...	...	...	...	...	...
"	1¾	4.15	4.93	5.68	6.42	7.15	7.85	8.54	...	...	...	...	...	...	...	...	...	...
"	2	4.32	5.14	5.94	6.72	7.49	8.23	8.97	9.68	...	...	...	...	...	...	...	...	...
"	2¼	4.49	5.35	6.19	7.02	7.83	8.62	9.39	10.15	...	...	...	...	...	...	...	...	...
3½	1¾	4.38	5.20	6.00	6.78	7.55	8.29	9.03	9.74	...	...	...	...	...	...	...	...	...
"	2	4.55	5.41	6.25	7.06	7.89	8.68	9.45	10.21	...	...	...	...	...	...	...	...	...
"	2¼	4.72	5.63	6.51	7.38	8.23	9.06	9.88	10.67	11.46	...	...	...	...	...	...	...	...
"	2½	4.89	5.84	6.76	7.67	8.57	9.44	10.30	11.14	11.97	...	...	...	...	...	...	...	...
3¾	1¾	4.61	5.47	6.31	7.14	7.95	8.74	9.51	10.27	...	...	...	...	...	...	...	...	...
"	2	4.78	5.69	6.57	7.44	8.29	9.12	9.94	10.73	...	...	...	...	...	...	...	...	...
"	2¼	4.95	5.90	6.82	7.73	8.63	9.50	10.36	11.20	12.03	...	...	...	...	...	...	...	...
"	2½	5.12	6.11	7.08	8.03	8.97	9.88	10.79	11.67	12.54	...	...	...	...	...	...	...	...
4	2	5.03	5.98	6.90	7.81	8.71	9.58	10.44	11.28	12.11	...	...	...	...	...	...	...	...
"	2¼	5.20	6.19	7.16	8.11	9.05	9.96	10.87	11.75	12.62	...	...	...	...	...	...	...	...
"	2½	5.37	6.40	7.41	8.41	9.39	10.36	11.29	12.22	13.13	14.02	14.89	...	...	...	...	...	...
"	2¾	5.54	6.62	7.67	8.71	9.73	10.73	11.72	12.68	13.64	14.57	15.49	...	...	...	...	...	...
4½	2	5.29	6.28	7.25	8.20	9.14	10.05	10.96	11.84	12.71	...	...	...	...	...	...	...	...
"	2¼	5.46	6.49	7.50	8.50	9.48	10.44	11.38	12.31	13.22	...	...	...	...	...	...	...	...
"	2½	5.63	6.71	7.76	8.80	9.82	10.82	11.81	12.77	13.73	14.66	15.58	...	...	...	...	...	...
"	2¾	5.80	6.92	8.01	9.09	10.16	11.20	12.23	13.24	14.24	15.21	16.17	...	...	...	...	...	...

Web.	Flange.	THICKNESS IN TWENTIETHS OF AN INCH.																
		$\frac{4}{20}$	$\frac{5}{20}$	$\frac{6}{20}$	$\frac{7}{20}$	$\frac{8}{20}$	$\frac{9}{20}$	$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{13}{20}$	$\frac{14}{20}$	$\frac{15}{20}$	$\frac{16}{20}$	$\frac{17}{20}$	$\frac{18}{20}$	$\frac{19}{20}$	$\frac{20}{20}$
4½	2¼	5.70	6.78	7.83	8.87	9.89	10.89	11.88	12.84	13.80	14.73	15.65		..	..		..	...
"	2½	5.87	6.99	8.08	9.16	10.23	11.27	12.30	13.31	14.31	15.28	16.24						
"	2¾	6.04	7.20	8.34	9.46	10.57	11.65	12.73	13.78	14.82	15.84	16.84	17.83					
"	3	6.21	7.41	8.59	9.76	10.91	12.04	13.15	14.25	15.33	16.39	17.43	18.46					
4¾	2¼	5.98	7.10	8.19	9.27	10.34	11.38	12.41	13.42	14.42	15.39	16.35						
"	2½	6.15	7.31	8.45	9.57	10.68	11.76	12.84	13.89	14.93	15.95	16.95						
"	2¾	6.32	7.52	8.70	9.87	11.02	12.15	13.26	14.36	15.44	16.50	17.54	18.57					
"	3	6.49	7.74	8.96	10.17	11.36	12.53	13.69	14.82	15.95	17.05	18.14	19.21					
5	2½	6.40	7.60	8.78	9.95	11.10	12.23	13.34	14.44	15.52	16.58	17.62	18.65					
"	2¾	6.57	7.82	9.04	10.25	11.44	12.61	13.77	14.90	16.03	17.13	18.22	19.29					
"	3	6.74	8.03	9.29	10.54	11.78	12.99	14.19	15.37	16.54	17.68	18.81	19.93	21.02				
"	3¼	6.91	8.24	9.55	10.84	12.12	13.37	14.62	15.84	17.05	18.24	19.41	20.57	21.70				
5¼	2½	6.66	7.91	9.13	10.34	11.53	12.70	13.86	14.99	16.12	17.22	18.31	19.38					
"	2¾	6.83	8.12	9.38	10.63	11.87	13.08	14.28	15.46	16.63	17.77	18.90	20.02					
"	3	7.00	8.33	9.64	10.93	12.21	13.46	14.71	15.93	17.14	18.33	19.50	20.66	21.79				
"	3¼	7.17	8.54	9.89	11.23	12.55	13.85	15.13	16.40	17.65	18.88	20.09	21.29	22.47				
5½	2¾	7.11	8.44	9.75	11.04	12.32	13.57	14.82	16.04	17.25	18.44	19.61	20.77	21.90				
"	3	7.28	8.65	10.00	11.34	12.66	13.96	15.24	16.51	17.76	18.99	20.20	21.40	22.58				
"	3¼	7.45	8.87	10.26	11.64	13.00	14.34	15.67	16.97	18.27	19.54	20.80	22.04	23.26	24.47			
"	3½	7.62	9.08	10.51	11.93	13.34	14.72	16.09	17.44	18.78	20.09	21.39	22.68	23.94	25.19			

Web.	Flange	Thickness in Twentieths of an Inch																
		$\frac{4}{20}$	$\frac{5}{20}$	$\frac{6}{20}$	$\frac{7}{20}$	$\frac{8}{20}$	$\frac{9}{20}$	$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{13}{20}$	$\frac{14}{20}$	$\frac{15}{20}$	$\frac{16}{20}$	$\frac{17}{20}$	$\frac{18}{20}$	$\frac{19}{20}$	$\frac{20}{20}$
5½	2¾		8 74	10.09	11.43	12 75	14.05	15.33	16.60	17 85	19.08	20 79	21.49	22.67				
''	3		8 96	10.35	11 73	13 09	14 43	15.76	17.06	18.36	19.63	20.89	22.13	23.35				
''	3¼		9 17	10.60	12.02	13.43	14 81	16.18	17.53	18.87	20.18	21 48	22.77	24.03	25.28			
''	3½		9 38	10.86	12 32	13 77	15.19	16.61	18.00	19.38	20.74	22.08	23 41	24.71	26.01			
6	2¾		9.07	10 46	11 84	13 20	14 54	15.87	17 17	18 47	19.74	21.00	22.24	23.46				
''	3		9 28	10 71	12 13	13.54	14 92	16.29	17.64	18 98	20 29	21.59	22.88	24.14				
''	3¼		9.49	10.97	12.43	13.88	15.30	16.72	18.11	19.49	20 85	22 19	23.52	24 82	26.12			
''	3½		9 70	11.22	12 73	14.22	15.69	17 14	18.58	20.00	21.40	22 78	24.15	25.50	26.84			
6½	2¾			11 17	12.63	14 08	15.50	16.92	18.31	19 69	21.05	22 39	23 72	25.02				
''	3			11 42	12 93	14 42	15 89	17 34	18.78	20 20	21.60	22 98	24.35	25 70				
''	3¼			11.68	13.23	14.76	16.27	17 77	19.24	20.71	22.15	23.58	24 99	26.38	27 76			
''	3½			11 93	13 52	15 10	16.65	18.19	19 71	21.22	22 70	24.17	25.63	27.06	28.84			
7	2¾			11 88	13 43	14 96	16 47	17 97	19.44	20 91	22.35	23 78	25 19	26 58				
''	3			12 13	13 72	15.30	16.85	18.39	19 91	21.42	22 90	24 37	25.83	27.26				
''	3¼			12 39	14.02	15.64	17 23	18 82	20 38	21 93	23 46	24 97	26.47	27.94	29.41			
''	3½			12.64	14.32	15.98	17.62	19 24	20.85	22.44	24 01	25 56	27 10	28 62	30 13			
7½	2¾			12.65	14 28	15 90	17.49	19 08	20.64	22.19	23 72	25.23	26 73	28.20				
''	3			12 90	14.58	16.24	17.88	19.50	21 11	22.70	24 27	25.82	27 36	28 88				
''	3¼			13 16	14.88	16 58	18 26	19 93	21.57	23.21	24.82	26 42	28.00	29.56	31 11			
''	3½			13.41	15.17	16 92	18.64	20.35	22.04	23.72	25.37	27 01	28.64	30.24	31.83			

Web.	Flange.	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
		Thickness in Twentieths of an Inch.																
8	3				15.38	17.13	18.85	20.56	22.25	23.93	25.58	27.22	28.85	30.48	32.04		..	.
"	3¼				15.68	17.47	19.23	20.99	22.72	24.44	26.14	27.82	29.49	31.13	32.77		.	..
"	3½				15.98	17.81	19.62	21.41	23.19	24.95	26.69	28.41	30.12	31.81	33.49	35.15	36.79	..
"	3¾				16.28	18.15	20.00	21.84	23.65	25.46	27.24	29.01	30.76	32.49	34.21	35.91	37.59	...
8½	3				16.24	18.07	19.88	21.67	23.45	25.21	26.95	28.67	30.38	32.07	33.75			.
"	3¼				16.54	18.41	20.26	22.10	23.91	25.72	27.50	29.27	31.02	32.75	34.47			
"	3½				16.83	18.75	20.64	22.52	24.38	26.23	28.05	29.86	31.66	33.43	35.19	36.94	38.66	
"	3¾				17.13	19.09	21.02	22.95	24.85	26.74	28.61	30.46	32.30	34.11	35.92	37.70	39.47	
9	3				17.10	19.02	20.91	22.79	24.65	26.50	28.32	30.13	31.93	33.70	35.46	37.21	39.93	
"	3¼				17.40	19.36	21.29	23.22	25.12	27.01	28.88	30.73	32.57	34.38	36.19	37.97	39.74	
"	3½				17.70	19.70	21.68	23.64	25.59	27.52	29.43	31.32	33.20	35.06	36.91	38.74	40.55	42.34
"	4				18.29	20.38	22.44	24.49	26.52	28.54	30.53	32.51	34.48	36.42	38.35	40.26	42.16	44.04
9½	3				17.97	19.97	21.95	23.91	25.86	27.79	29.70	31.59	33.47	35.33	37.18	39.01	40.82	
"	3¼				18.27	20.31	22.33	24.34	26.32	28.30	30.25	32.19	34.11	36.01	37.90	39.77	41.62	
"	3½		.	.	18.56	20.65	22.71	24.76	26.79	28.81	30.80	32.78	34.75	36.69	38.62	40.53	42.43	44.31
"	4				19.16	21.33	23.48	25.61	27.73	29.83	31.91	33.97	36.02	38.05	40.07	42.07	44.05	46.01
10	3				.	20.94	23.00	25.05	27.08	29.10	31.09	33.07	35.04	36.98	38.91	40.83	42.72	
"	3¼				..	21.28	23.38	25.48	27.55	29.61	31.65	33.67	35.68	37.66	39.64	41.59	43.53	
"	3½	.	.			21.62	23.77	25.90	28.02	30.12	32.20	34.26	36.31	38.34	40.36	42.36	44.34	46.30
"	4	...	...	...	...	22.30	24.53	26.75	29.95	31.14	33.30	35.45	37.59	39.70	41.80	43.89	45.95	48.00

Web.	Flange.	Thickness in Twentieths of an Inch.																
		$\frac{4}{20}$	$\frac{5}{20}$	$\frac{6}{20}$	$\frac{7}{20}$	$\frac{8}{20}$	$\frac{9}{20}$	$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{13}{20}$	$\frac{14}{20}$	$\frac{15}{20}$	$\frac{16}{20}$	$\frac{17}{20}$	$\frac{18}{20}$	$\frac{19}{20}$	$\frac{20}{20}$
10½	3					21.90	24.05	26.18	28.30	30.40	32.48	34.54	36.59	38.62	40.64	42.64	44.62	...
"	3¼					22.24	24.43	26.61	28.76	30.91	33.03	35.14	37.23	39.30	41.30	43.40	45.42	
"	3½					22.58	24.81	27.03	29.23	31.42	33.58	35.73	37.87	39.98	42.08	44.17	46.23	48.28
"	4					23.26	25.58	27.88	30.17	32.44	34.69	36.92	39.14	41.34	43.53	45.70	47.85	49.98
11	3½					23.57	25.89	28.19	30.48	32.75	35.00	37.23	39.45	41.65	43.84	46.01	48.16	50.29
"	3¾					23.91	26.27	28.62	30.94	33.26	35.55	37.83	40.09	42.33	44.56	46.77	48.96	51.14
"	4					24.25	26.65	29.04	31.41	33.77	36.10	38.42	40.73	43.01	45.28	47.54	49.77	51.99
"	4½					24.93	27.42	29.89	32.35	34.79	37.21	39.61	42.00	44.37	46.73	49.07	51.39	53.69
11½	3½					24.58	26.98	29.37	31.74	34.10	36.43	38.75	41.06	43.34	45.61	47.87	50.10	52.32
"	3¾					24.92	27.36	29.79	32.21	34.61	36.99	39.35	41.70	44.02	46.34	48.63	50.91	53.17
"	4					25.62	27.75	30.22	32.68	35.12	37.54	39.94	42.33	44.70	47.06	49.40	51.72	54.02
"	4½					25.94	28.51	31.07	33.61	36.14	38.64	41.13	43.61	46.06	48.50	50.93	53.33	55.72
12	3½					25.60	28.09	30.56	33.02	35.46	37.88	40.28	42.67	45.04	47.40	49.74	52.06	54.36
"	3¾					25.94	28.47	30.98	33.48	35.97	38.43	40.88	43.31	45.72	48.12	50.50	52.86	55.21
"	4					26.28	28.85	31.41	33.95	36.48	38.98	41.47	43.95	46.40	48.84	51.27	53.67	56.06
"	4½					26.96	29.62	32.26	34.89	37.50	40.09	42.66	45.22	47.76	50.29	52.80	55.29	57.76
12½	3½					26.64	29.21	31.77	34.31	36.84	39.34	41.83	44.31	46.76	40.20	51.63	54.03	56.42
"	3¾					26.98	29.59	32.19	34.78	37.35	39.90	42.43	44.95	47.44	49.93	52.39	54.84	57.27
"	4					27.32	29.98	32.62	35.25	37.86	40.45	43.02	45.58	48.12	50.65	53.16	55.65	58.12
"	4½					28.00	30.74	33.47	36.18	38.88	41.55	44.21	46.86	49.48	52.00	54.69	57.26	59.82

STEEL SHIPBUILDING SECTIONS. — BULB-PLATE.

Weight in Pounds per Foot Run.

Depth. (Ins.)	$\frac{4}{20}$	$\frac{5}{20}$	$\frac{6}{20}$	$\frac{7}{20}$	$\frac{8}{20}$	$\frac{9}{20}$	$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{13}{20}$	$\frac{14}{20}$	$\frac{15}{20}$	$\frac{16}{20}$	$\frac{17}{20}$	$\frac{18}{20}$	$\frac{19}{20}$	1	$1\frac{1}{20}$	$1\frac{2}{20}$	$1\frac{3}{20}$	$1\frac{4}{20}$	$1\frac{5}{20}$
	Thickness in Twentieths of an Inch.																					
2	1.63	1.97	2.31	2.65	. .		.		. .	.	. .	.	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
$2\frac{1}{4}$	1.84	2.22	2.60	2.99	. .	. .	. .	.	.	.	.	. .	. .	.	. .	. .	. .	. .	. .	. .	. .	. .
$2\frac{1}{2}$	2.07	2.49	2.92	3.34	3.77	4.19	.		.	.	.	.		.	.	. .	. .	. .	. .	. .	.	. .
$2\frac{3}{4}$	2.31	2.78	3.24	3.71	4.18	4.65	.	. .		.	.	. .	. .	. .	.	.	. .	. .	. .	. .	. .	.
3	2.52	3.03	3.54	4.05	4.56	5.07	5.58	6.09	.	.	. .	. .	. .	. .	. .	. .	.	. .	. .	. .	. .	. .
$3\frac{1}{4}$	2.75	3.30	3.85	4.41	4.96	5.51	6.06	6.62	. .	.	.		. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
$3\frac{1}{2}$	2.99	3.58	4.18	4.77	5.37	5.96	6.56	7.15	7.75	8.34	.	. .	.	. .	. .	. .	. .	. .	.	.	. .	. .
$3\frac{3}{4}$	3.24	3.88	4.51	5.15	5.79	6.43	7.06	7.70	8.34	8.98	.	.	. .	.	. .	. .	. .	. .	.	. .	. .	. .
4	3.47	4.15	4.83	5.51	6.19	6.87	7.55	8.23	8.91	9.59	10.27	10.95		. .	. .	. .	.	. .	. .	. .	. .	. .
$4\frac{1}{4}$	3.70	4.42	5.14	5.87	6.59	7.31	8.03	8.76	9.48	10.20	10.92	11.65	. .	. .	. .	. .	. .	. .	. .	.	. .	. .
$4\frac{1}{2}$	3.97	4.73	5.50	6.26	7.03	7.79	8.55	9.32	10.09	10.85	11.62	12.38	13.15	13.91	. .	. .	. .	. .	. .	. .	. .	. .
$4\frac{3}{4}$	4.22	5.03	5.83	6.64	7.45	8.26	9.06	9.87	10.68	11.49	12.29	13.10	13.91	14.72	.	. .	. .	. .	.	. .	. .	. .
5	4.49	5.34	6.19	7.04	7.89	8.74	9.59	10.44	11.29	12.14	12.99	13.84	14.69	15.54	16.39	17.24	. .	. .	. .	. .	. .	. .
$5\frac{1}{4}$	4.66	5.55	6.44	7.34	8.23	9.12	10.01	10.91	11.80	12.69	13.58	14.48	15.37	16.26	17.15	18.05	. .	.	. .	. .	. .	. .
$5\frac{1}{2}$	4.83	5.76	6.70	7.63	8.57	9.50	10.44	11.37	12.31	13.24	14.18	15.11	16.05	16.98	17.92	18.85	19.79	20.7	21.7	.	. .	. .
6	5.53	6.55	7.57	8.59	9.61	10.63	11.65	12.67	13.69	14.71	15.73	16.75	17.77	18.79	19.81	20.83	21.85	22.9	23.9	. .	. .	.
$6\frac{1}{2}$	5.87	6.97	8.08	9.18	10.29	11.39	12.50	13.60	14.71	15.81	16.92	18.02	19.13	20.23	21.34	22.44	23.54	24.7	25.8	26.9	28.0	29.1
7	. .	7.86	9.05	10.24	11.43	12.62	13.81	15.00	16.19	17.38	18.57	19.76	20.96	22.14	23.33	24.52	25.71	26.9	28.1	29.3	30.5	31.7
$7\frac{1}{2}$	. .	8.28	9.56	10.83	12.11	13.38	14.66	15.93	17.21	18.48	19.76	21.03	22.31	23.58	24.86	26.13	27.41	28.7	30.0	31.2	32.5	33.8
8	. .	. .	10.57	11.93	13.29	14.65	16.01	17.37	18.73	20.09	21.45	22.81	24.17	25.53	26.89	28.25	29.61	31.0	32.3	33.7	35.0	36.4

Depth. (Ins.)	Thickness in Twentieths of an Inch.																					
	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	1	1 1/20	1 2/20	1 3/20	1 4/20	1 5/20
8½	...	...	11.08	12.52	13.97	15.41	16.86	18.30	19.75	21.19	22.64	24.08	25.53	26.97	28.42	29.86	31.31	32.8	34.2	35.6	37.1	38.5
9	...	...	12.16	13.69	15.22	16.75	18.28	19.81	21.34	22.87	24.40	25.93	27.46	28.99	30.52	32.06	33.58	35.1	36.6	38.2	39.7	41.2
9½	...	...	...	14.28	15.90	17.51	19.13	20.74	22.36	23.97	25.59	27.20	28.82	30.43	32.05	33.66	35.28	36.9	38.5	40.1	41.7	43.4
10	...	...	...	15.55	17.25	18.95	20.65	22.35	24.05	25.75	27.45	29.15	30.85	32.55	34.25	35.95	37.65	39.3	41.0	42.7	44.4	46.1
10½	...	...	...	...	17.93	19.71	21.50	23.28	25.07	26.85	28.64	30.42	32.21	33.99	35.78	37.56	39.35	41.1	42.9	44.7	46.5	48.3
11	...	...	...	...	19.28	21.13	23.00	24.87	26.74	28.61	30.48	32.35	34.22	36.09	37.96	39.83	41.70	43.6	45.4	47.3	49.2	51.0
11½	...	...	...	...	19.94	21.89	23.85	25.80	27.76	29.71	31.67	33.62	35.58	37.53	39.49	41.44	43.40	45.4	47.3	49.3	51.2	53.2
12	...	...	...	...	...	23.42	25.46	27.50	29.54	31.58	33.62	35.66	37.70	39.74	41.78	43.82	45.86	47.9	49.9	52.0	54.0	56.1
12½	...	...	...	...	...	24.18	26.31	28.43	30.54	32.66	34.81	36.93	39.06	41.18	43.31	45.43	47.56	49.7	51.8	53.9	56.1	58.2
13	...	...	...	...	...	25.74	27.95	30.16	32.37	34.58	36.79	39.00	41.21	43.42	45.63	47.84	50.04	52.3	54.5	56.7	58.9	61.1
13½	...	...	...	...	...	26.50	28.80	31.09	33.30	35.68	37.98	40.27	42.57	44.86	47.16	49.45	51.74	54.0	56.3	58.6	60.9	63.2
14	...	...	...	...	...	28.14	30.52	32.90	35.28	37.66	40.04	42.42	44.80	47.18	49.56	51.93	54.31	56.7	59.1	61.5	63.8	66.2
14½	...	...	...	...	...	...	31.37	33.83	36.24	38.76	41.23	43.69	46.16	48.62	51.08	53.55	56.01	58.5	60.9	63.4	65.9	68.3
15	...	...	...	...	...	...	33.15	35.70	38.25	40.80	43.35	45.90	48.45	50.99	53.54	56.09	58.64	61.2	63.7	66.3	68.8	71.4
15½	...	...	...	...	...	...	34.00	36.63	39.27	41.90	44.54	47.17	49.81	52.44	55.07	57.71	60.34	63.0	65.6	68.2	70.9	73.5
16	...	...	...	...	...	...	...	38.54	41.26	43.98	46.70	49.42	52.13	54.85	57.57	60.29	63.01	65.7	68.5	71.2	73.9	76.6
16½	...	...	...	...	...	...	...	39.47	42.28	45.08	47.89	50.69	53.49	56.30	59.10	61.91	64.71	67.5	70.3	73.1	75.9	78.7
17	...	...	...	...	...	...	...	...	44.38	47.27	50.16	53.04	55.93	58.82	61.71	64.60	67.49	70.4	73.3	76.2	79.1	81.9
17½	...	...	...	...	...	...	...	...	45.40	48.37	51.35	54.32	57.29	60.27	63.24	66.22	68.19	72.2	75.1	78.1	81.1	84.1
18	...	...	...	...	...	...	...	...	47.53	50.59	53.64	56.70	59.76	62.82	65.88	68.94	72.00	75.1	78.1	81.2	84.2	87.3

STEEL SHIPBUILDING SECTIONS.—BULB-TEE.

Weight in Pounds per Foot Run.

Depth. (Ins.)	Breadth of Flange. (Ins.)	Thickness in Twentieths of an Inch. $\frac{4}{20}$	$\frac{5}{20}$	$\frac{6}{20}$	$\frac{7}{20}$	$\frac{8}{20}$	$\frac{9}{20}$	$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{13}{20}$	$\frac{14}{20}$	$\frac{15}{20}$	$\frac{16}{20}$	$\frac{17}{20}$	$\frac{18}{20}$	$\frac{19}{20}$	$\frac{20}{20}$
2	2	2.99	3.67	4.35	5.03													
"	$2\frac{1}{4}$	3.16	3.88	4.60	5.33													
"	$2\frac{1}{2}$	3.33	4.09	4.86	5.62													
"	3	3.67	4.52	5.37	6.22													
$2\frac{1}{4}$	$2\frac{1}{8}$	3.28	4.03	4.78	5.52													
"	$2\frac{3}{8}$	3.45	4.24	5.02	5.82													
"	$2\frac{5}{8}$	3.62	4.45	5.28	6.11													
"	$3\frac{1}{8}$	3.96	4.88	5.79	6.71													
$2\frac{1}{2}$	$2\frac{1}{4}$	3.60	4.40	5.21	6.02	6.83	7.63											
"	$2\frac{1}{2}$	3.77	4.61	5.47	6.31	7.17	8.01											
"	$2\frac{3}{4}$	3.94	4.83	5.72	6.61	7.51	8.40											
"	$3\frac{1}{4}$	4.28	5.25	6.23	7.21	8.19	9.16											
$2\frac{3}{4}$	$2\frac{3}{8}$	3.92	4.80	5.66	6.54	7.41	8.28											
"	$2\frac{5}{8}$	4.09	5.01	5.92	6.83	7.75	8.67											
"	$2\frac{7}{8}$	4.26	5.22	6.17	7.13	8.09	9.05											
"	$3\frac{3}{8}$	4.60	5.65	6.68	7.73	8.77	9.81											
3	$2\frac{1}{2}$	4.22	5.15	6.09	7.02	7.96	8.89	9.85	10.76									
"	$2\frac{3}{4}$	4.39	5.37	6.34	7.32	8.30	9.28	10.25	11.23									
"	3	4.56	5.58	6.60	7.62	8.64	9.66	10.68	11.70									
"	$3\frac{1}{2}$	4.90	6.00	7.11	8.21	9.32	10.42	11.53	12.63									

Depth. (Ins.)	Breadth of Flange. (Ins.)	Thickness in Twentieths of an Inch. $\frac{4}{20}$	$\frac{5}{20}$	$\frac{6}{20}$	$\frac{7}{20}$	$\frac{8}{20}$	$\frac{9}{20}$	$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{13}{20}$	$\frac{14}{20}$	$\frac{15}{20}$	$\frac{16}{20}$	$\frac{17}{20}$	$\frac{18}{20}$	$\frac{19}{20}$	$\frac{20}{20}$
3¼	2⅝	4.53	5.53	6.53	7.53	8.53	9.53	10.52	11.53	...	...	...	...	...	...		...	...
"	2⅞	4.70	5.74	6.78	7.83	8.87	9.91	10.95	12.00	...	...	...	...	...	...	...	...	...
"	3⅛	4.87	5.96	7.04	8.13	9.21	10.29	11.37	12.46	...	...	...	...	...	...	...	...	...
"	3⅝	5.21	6.38	7.55	8.72	9.89	11.06	12.22	13.40	...	...	...	...	...	...	...	...	...
3½	2¾	4.86	5.92	6.98	8.04	9.11	10.17	11.23	12.29	13.36	14.42	...	...	...	...	...	...	...
"	3	5.03	6.13	7.24	8.34	9.45	10.55	11.66	12.76	13.87	14.97	...	...	...	...	...	...	...
"	3¼	5.20	6.34	7.49	8.64	9.79	10.93	12.08	13.23	14.38	15.52	...	...	...		...	...	...
"	3¾	5.54	6.77	8.00	9.23	10.47	11.70	12.93	14.16	15.40	16.63	...	...	...	...	...	...	...
3¾	2⅞	5.19	6.32	7.44	8.57	9.70	10.83	11.95	13.08	14.20	15.33	...	...	...	...	...	...	
"	3⅛	5.36	6.54	7.70	8.87	10.04	11.21	12.37	13.54	14.71	15.89	...	...	...	...	...	...	...
"	3⅜	5.53	6.75	7.95	9.17	10.38	11.59	12.80	14.01	15.22	16.44	...		...	...	...	...	...
"	3⅞	5.87	7.17	8.46	9.76	11.06	12.36	13.65	14.95	16.24	17.54	...	...	...	...	...	...	...
4	3	5.51	6.70	7.89	9.08	10.27	11.46	12.65	13.84	15.03	16.22	17.41	18.60	...		...	...	...
"	3¼	5.68	6.91	8.14	9.38	10.61	11.84	13.07	14.31	15.54	16.77	18.00	19.24	...			...	...
"	3½	5.85	7.12	8.40	9.67	10.95	12.22	13.50	14.77	16.05	17.32	18.60	19.87	...	...	...	...	...
"	4	6.19	7.55	8.91	10.27	11.63	12.99	14.35	15.71	17.07	18.43	19.79	21.15	...	...	...	...	...
4¼	3⅛	5.82	7.08	8.33	9.59	10.84	12.09	13.34	14.60	15.85	17.11	18.36	19.62		...	...	...	...
"	3⅜	5.99	7.29	8.58	9.89	11.18	12.47	13.77	15.07	16.36	17.66	18.95	20.28	...			...	...
"	3⅝	6.16	7.50	8.84	10.18	11.52	12.86	14.19	15.54	16.87	18.21	19.55	20.89	...	...		...	...
"	4⅛	6.50	7.93	9.35	10.78	12.20	13.62	15.05	16.47	17.89	19.32	20.74	22.17	...			...	...

Depth. (Ins.)	Breadth of Flange. (Ins.)	Thickness in Twentieths of an Inch. 4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
4½	3¼	6.18	7.49	8.81	10.13	11.46	12.76	14.07	15.40	16.72	18.03	18.35	20.67	21.99	23.30	.	. .	.
"	3½	6.35	7.70	9.07	10.42	11.79	13.14	14.50	15.86	17.23	18.58	19.95	21.30	22.67	24.02	...	. .	...
"	3¾	6.52	7.92	9.32	10.72	12.13	13.53	14.92	16.33	17.74	19.14	20.54	21.94	23.35	24.75	...	. .	...
"	4¼	6.86	8.34	9.83	11.32	12.81	14.29	15.77	17.27	18.76	20.24	21.73	23.22	24.71	26.19	...	.	. .
4¾	3¼	6.51	7.90	9.27	10.66	12.04	13.42	14.80	16.18	17.56	18.95	20.32	21.71	23.09	24.47	...	. .	...
"	3½	6.68	8.11	9.53	10.95	12.38	13.81	15.22	16.65	18.07	19.50	20.92	22.34	23.77	25.20	. .	.	. .
"	3¾	6.85	8.32	9.78	11.25	12.72	14.19	15.65	17.12	18.58	20.05	21.51	22.98	24.45	25.92	.	.	...
"	4¼	7.19	8.75	10.29	11.85	13.40	14.95	16.50	18.05	19.60	21.16	22.70	24.25	25.81	27.36	. .		. .
5	3½	6.87	8.31	9.76	11.20	12.65	14.09	15.54	16.98	18.43	19.87	21.32	22.76	24.21	25.65	27.10	28.54	...
"	3¾	7.04	8.53	10.01	11.50	12.99	14.48	15.96	17.45	18.94	20.43	21.91	23.40	24.89	26.38	27.86	29.35	...
"	4	7.21	8.74	10.27	11.80	13.33	14.86	16.39	17.92	19.45	20.98	22.51	24.04	25.57	27.10	28.63	30.16	.
"	4½	7.55	9.16	10.78	12.39	14.01	15.62	17.24	18.85	29.47	22.08	22.70	25.31	26.93	28.54	30.16	31.77	...
5¼	3½	7.12	8.63	10.14	11.65	13.16	14.67	16.17	17.69	19.19	20.70	21.32	23.72	25.23	26.74	28.24	29.76	...
"	3¾	7.29	8.84	10.39	11.95	13.50	15.05	16.60	18.16	19.70	21.25	21.91	24.36	25.91	27.46	29.01	30.56	...
"	4¼	7.46	9.06	10.65	12.25	13.84	15.43	17.03	18.62	20.21	21.81	22.51	25.00	26.60	28.18	29.77	31.37	...
"	4½	7.80	9.48	11.16	12.84	14.52	16.20	17.87	19.56	21.23	22.91	23.70	26.27	27.95	29.62	31.30	32.99	. .
5½	3¾	7.38	8.95	10.52	12.09	13.67	15.24	16.81	18.38	19.96	21.53	23.10	24.67	26.25	27.82	29.39	30.96	32.54
"	4	7.55	9.16	10.78	12.39	14.01	15.62	17.24	18.85	20.47	22.08	23.70	25.31	26.93	28.54	30.16	31.77	33.39
"	4¼	7.72	9.37	11.03	12.69	14.35	16.00	17.66	19.32	20.98	22.63	24.29	25.95	27.61	29.26	30.92	32.58	34.24
"	4½	8.06	9.80	11.54	13.28	15.03	16.77	18.51	20.25	22.00	23.74	25.48	27.22	28.97	30.71	32.45	34.19	35.94

Depth. (Ins.)	Breadth of Flange. (Ins.)	Thickness in Twentieths of an Inch.																
		4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
6	4	8.25	9.95	11.65	13.35	15.05	16.75	18.45	20.15	21.85	23.55	25.25	26.95	28.65	30.35	32.05	33.75	35.45
"	4¼	8.42	10.16	11.90	13.65	15.39	17.13	18.87	20.62	22.36	24.10	25.84	27.59	29.33	31.07	32.81	34.56	36.30
"	4½	8.59	10.37	12.16	13.94	15.73	17.51	19.30	21.08	22.87	24.65	26.44	28.22	30.01	31.79	33.58	35.36	37.15
"	5	8.93	10.80	12.67	14.54	16.41	18.28	20.15	22.02	23.89	25.76	27.63	29.50	31.37	33.24	35.11	36.98	38.85
6½	4¼	8.76	10.58	12.41	14.24	16.07	17.89	19.72	21.55	23.38	25.20	27.03	28.86	30.69	32.51	34.34	36.17	37.99
"	4½	8.93	10.79	12.67	14.53	16.41	18.27	20.15	22.01	23.89	25.75	27.63	29.49	31.37	33.23	35.11	36.97	38.84
"	4¾	9.10	11.01	12.92	14.83	16.75	18.66	20.57	22.48	24.40	26.31	28.22	30.13	32.05	33.96	35.87	37.78	39.69
"	5¼	9.44	11.43	13.43	15.43	17.43	19.42	21.42	23.42	25.42	27.41	29.41	31.41	33.41	35.40	37.40	39.40	41.39
7	4½		11.68	13.64	15.59	17.55	19.50	21.46	23.41	25.37	27.32	29.28	31.23	33.19	35.14	37.10	39.05	41.01
"	4¾		11.90	13.89	15.89	17.89	19.89	21.88	23.88	25.88	27.88	29.87	31.87	33.87	35.87	37.86	39.86	41.86
"	5		12.11	14.15	16.19	18.23	20.27	22.31	24.35	26.39	27.43	30.47	32.51	34.55	36.59	38.63	40.67	42.71
"	5½		12.53	14.66	16.78	18.91	21.03	23.16	25.28	27.41	29.53	31.66	33.78	35.91	38.03	40.16	42.28	44.41
7½	4¾		12.32	14.40	16.48	18.57	20.65	22.73	24.81	26.90	28.98	31.06	33.14	35.23	37.31	39.39	41.47	43.56
"	5		12.53	14.66	16.78	18.91	21.03	23.16	25.28	27.41	29.53	31.66	33.78	35.91	38.03	40.16	42.28	44.41
"	5¼		12.74	14.91	17.08	19.25	21.41	23.58	25.75	27.92	30.08	32.25	34.42	36.59	38.75	40.92	43.13	45.26
"	5½		13.17	15.42	17.67	19.93	22.18	24.43	26.68	28.94	31.19	33.44	35.69	37.95	40.20	42.45	44.70	46.96
8	5			15.67	17.88	20.09	22.30	24.51	26.72	28.93	31.14	33.35	35.56	37.77	39.98	42.19	44.40	46.61
"	5¼			15.92	18.18	20.43	22.68	24.93	27.19	29.44	31.69	33.94	36.20	38.45	40.70	42.95	45.21	47.46
"	5½			16.18	18.47	20.77	23.06	25.36	27.65	29.95	32.24	34.54	36.83	39.13	41.42	43.72	46.01	48.31
"	6			16.69	19.07	21.45	23.83	26.21	28.59	30.97	33.35	35.73	38.11	40.49	42.87	45.25	47.63	50.01

Depth. (Ins.)	Breadth of Flange. (Ins.)	Thickness in Twentieths of an Inch.																
		4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
8½	5¼			16 31	18.62	20 94	23.25	25 57	27.88	30.20	32.51	34.84	37.15	39.47	41 78	44.10	46.41	48.73
"	5½			16 56	18 92	21 28	23.63	26.00	27 35	30 71	33.07	35.43	37 78	40 15	42.50	44.87	47 22	49.58
"	5¾			16.82	19 21	21 62	24.02	26 42	28.82	31.22	33.62	36.03	38.42	40.83	43.22	45.63	48.03	50.43
"	6¼			17 33	19 81	22 30	24 78	27 27	29 75	32.24	34.72	37 22	39.70	42.19	44.67	47.16	49.64	52.13
9	5¼			17 51	19 94	22 36	24 78	27 20	29.63	32.05	34 47	36.89	39.32	41 74	44 16	46.58	49.01	51.43
"	5½			17 77	20 23	22 70	25.16	27.63	30.09	32.56	35 02	37 49	39.95	42 42	44.88	47.35	49 81	52.28
"	5¾			18.02	20 53	23.04	25 55	28.05	30.56	33.07	35.58	38.08	40.59	43 10	45.61	48 11	50 62	53 13
"	6¼			18.53	21 13	23 72	26 31	28 90	31.50	34 09	36.68	39.27	41.87	44 46	47.05	49.64	52.24	54.83
9½	5½				20 82	23 38	25.92	28.48	31.02	33.58	35 12	38.68	41.22	43 78	46.32	48.88	51 42	53 98
"	5¾				21 12	23 72	26 31	28 90	31.49	34.09	36.68	39.27	41 86	44.46	47.05	49 64	52 23	54.83
"	6				21 42	24.06	26.69	29 33	31 96	34.60	37 23	39.87	42.50	45 14	47 77	50.41	53.04	55.68
"	6½			.	22.01	24 74	27.45	30 18	32.89	35.62	38 33	41.06	43.77	46.50	49.21	51.94	54.65	57.38
10	5¾	.	.	.	22 39	25.07	27 75	30 42	33 10	35 78	38.46	41 13	43.71	46 49	49.17	51.84	54 52	57.20
"	6	.	.	.	22.69	25 41	28.13	30.85	33.57	36.29	39.01	41 73	44.45	47 17	49.89	52.61	55.33	58.05
"	6¼	.		.	22.99	25 75	28 51	31 27	34.04	36.80	39.56	42 32	45.09	47.05	50.61	53.37	56 14	58.90
"	6¾	. .	.		23 58	26.43	29 28	32.12	34.97	37.82	40.67	43.51	46.36	49 21	52.06	54.90	57.75	60.60
10½	5¾	. .	. .	. .	23 13	25 92	28 70	31.49	34.26	37 05	39.83	42.62	45.40	48 19	50 97	53.76	56.53	59.32
"	6¼	.	.		23.43	26.26	29.08	31 91	34.83	37.56	40 38	43 22	46.04	48.87	51 69	54 52	57.34	60.17
"	6½	. . .	. .	. .	23 73	26.60	29 46	32 34	35 30	38.07	40 94	43.81	46.67	49.55	52.41	55 29	58 15	61.02
"	7	. . .	. .		24.47	27.45	30 42	33.40	36.47	39.35	42.32	45.30	48.27	51 25	54 22	57 20	60.17	63.15

Depth. (Ins.)	Breadth of Flange. (Ins.)	Thickness in Twentieths of an Inch. 4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
11	6					27.42	30.31	33.20	36.09	38.98	41.87	44.76	47.65	50.54	53.43	56.32	59.21	62.10
"	6¼					27.76	30.69	33.62	36.56	39.49	42.42	45.35	48.29	51.22	54.15	57.08	60.02	62.95
"	6½					28.10	31.07	34.05	37.02	40.00	42.97	45.95	48.92	51.90	54.87	57.85	60.82	63.80
"	7¼					29.12	32.22	35.32	38.43	41.53	44.63	47.73	50.84	53.94	57.04	60.14	63.24	66.35
11½	6¼					28.44	31.45	34.47	37.49	40.51	43.52	46.54	49.56	52.58	55.59	58.61	61.63	64.65
"	6½					28.78	31.83	34.90	37.95	41.02	44.07	47.14	50.19	53.26	56.31	59.38	62.43	65.50
"	6¾					29.12	32.22	35.32	38.42	41.53	44.63	47.73	50.83	53.94	57.04	60.14	63.24	66.35
"	7¼					29.80	32.98	36.17	39.36	42.55	45.73	48.92	52.11	55.30	58.48	61.67	64.85	68.05
12	6¼						32.98	36.08	39.19	42.29	45.39	48.49	51.60	54.70	58.80	60.90	64.01	67.11
"	6½						33.36	36.51	39.65	42.80	45.94	49.09	52.23	55.38	58.52	61.67	64.81	67.96
"	6¾						33.75	36.93	40.12	43.31	46.50	49.68	52.87	56.06	59.25	62.43	65.62	68.81
"	7¼						34.51	37.78	41.06	44.33	47.60	50.87	54.15	57.42	60.69	63.96	67.23	70.51
12½	6¼						33.74	36.93	40.12	43.29	46.49	49.68	52.87	56.06	59.24	62.43	65.62	68.81
"	6½						34.12	37.36	40.58	43.80	47.04	50.28	53.50	56.74	59.96	63.20	66.42	69.66
"	6¾						34.51	37.78	41.05	44.31	47.60	50.87	54.14	57.42	60.69	63.96	67.23	70.51
"	7¼						35.27	38.63	41.99	45.33	48.70	52.06	55.42	58.78	62.13	65.49	68.84	72.21
13	6¼						35.30	38.57	41.85	45.12	48.39	51.66	54.94	58.21	61.48	64.75	68.03	71.29
"	6½						35.68	39.00	42.31	45.63	48.94	52.26	55.57	58.89	62.20	65.52	68.83	72.14
"	6¾						36.07	39.42	42.78	46.14	49.50	52.85	56.21	59.57	62.93	66.28	69.64	72.99
"	7¼						36.83	40.27	43.72	47.16	50.60	54.04	57.49	60.93	64.37	67.81	71.25	74.69

Depth. (Ins.)	Breadth of Flange. (Ins.)	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
		Thickness in Twentieths of an Inch.																
13½	6¼						36.06	39.42	42.78	46.14	49.49	52.85	56.21	59.57	62.92	66.28	69.64	72.99
"	6½						36.44	39.85	43.24	46.65	50.04	53.45	56.84	60.25	63.64	67.05	70.44	73.84
"	6¾						36.83	40.27	43.71	47.16	50.60	54.04	57.48	60.93	64.37	67.81	71.25	74.69
"	7¼						37.59	41.12	44.65	48.18	51.70	55.23	58.76	62.29	65.81	69.34	72.86	76.39
14	6¼						37.70	41.14	44.59	48.03	51.47	54.91	58.36	61.80	65.24	68.67	72.12	75.56
"	6½						38.08	41.57	45.05	48.54	52.02	55.51	58.99	62.48	65.96	69.44	72.92	76.41
"	6¾						38.47	41.99	45.52	49.05	52.58	56.10	59.63	63.16	66.69	70.20	73.73	77.26
"	7¼						39.23	42.84	46.46	50.07	53.68	57.29	60.91	64.52	68.13	71.73	75.34	78.96
14½	6¼							41.99	45.52	48.99	52.57	56.10	59.63	63.16	66.68	70.20	73.74	77.26
"	6½							42.42	45.98	49.50	53.12	56.70	60.26	63.84	67.40	70.97	74.54	78.11
"	6¾							42.84	46.45	50.01	53.68	57.29	60.90	64.52	68.13	71.73	75.35	78.96
"	7¼							43.69	47.39	51.03	54.78	58.48	62.18	65.88	69.57	73.26	76.96	80.66
15	6¼							43.77	47.39	51.00	54.61	58.22	61.84	65.45	69.05	72.66	76.28	79.89
"	6½							44.20	47.85	51.51	55.16	58.82	62.47	66.13	69.77	73.43	77.08	80.74
"	6¾							44.62	48.32	52.02	55.72	59.41	63.11	66.81	70.50	74.19	77.89	81.59
"	7¼							45.47	49.26	53.04	56.82	60.60	64.39	68.17	71.94	75.72	79.50	83.29
15½	6¼							44.62	48.32	52.02	55.71	59.41	63.11	66.81	70.50	74.19	77.90	81.59
"	6½							45.05	48.78	52.53	56.26	60.01	63.74	67.49	71.22	74.96	78.70	82.44
"	6¾							45.47	49.25	53.04	56.82	60.60	64.38	68.17	71.95	75.72	79.51	83.29
"	7¼							46.32	50.19	54.06	57.92	61.79	65.66	69.53	73.39	77.25	81.12	84.99

Depth. (Ins.)	Breadth of Flange. (Ins.)	Thickness in Twentieths of an Inch.																
		4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20
16	6¼								50.23	54.01	57.79	61.57	65.36	69.13	72 91	76.69	80.48	84 26
"	6½								50.69	54 52	58.34	62 17	65.99	69.81	73.63	77.46	81 28	85.11
"	6¾								51.16	55.03	58.90	62.76	66.63	70.49	74 36	78.22	82.09	85 96
"	7¼								52.10	56.05	60.00	63.95	67.91	71.85	75.80	79.75	83 70	87.66
16½	6¼								51 16	55.03	58.89	62.76	66.63	70.49	74.36	78.22	82 10	85.96
"	6½								51.62	55.54	59.44	63.36	67.26	71.17	75.08	78 99	82 90	86.81
"	6¾								52.09	56 05	60.00	63.95	67.90	71.85	75.81	79.75	83.71	87.66
"	7¼								53.03	57.07	61.10	65.14	69.18	73.21	77.25	81.28	85.32	89.36
17	6¼									57.13	61.08	65.03	68.98	72 93	76.88	80.83	84.79	88.74
"	6½									57.64	61.63	65.63	69.61	73.61	77.60	81.60	85 59	89.59
"	6¾									58.15	62 19	66 22	70.25	74.29	78.33	82.36	86.40	90.44
"	7¼									59.17	63.29	67.41	71.53	75.65	79.77	83.89	88.01	92.14
17½	6¼									58 15	62 18	66 22	70.26	74.29	78.33	82.36	86.41	89.44
"	6½									58.66	62.73	66 82	70.89	74 97	79.05	83 13	87.21	90.29
"	6¾									59.17	63.29	67 41	71.53	75.65	79.78	83.89	88.02	91.14
"	7¼									60 19	64 39	68.60	72.81	77.01	81.22	85.42	89.63	92.84
18	6¼									60.28	64.40	68.51	72.64	76 76	80.88	85.00	89 13	93.25
"	6½									60 79	64.95	69 11	73.27	77.44	81.60	85.77	89 93	94 60
"	6¾									61.30	65.51	69 70	73 91	78 12	82 33	86.53	90 74	94 95
"	7¼									62.32	66.61	70.89	75.19	79.48	83 77	88 06	92 35	96.65

Outside Diameter.		Thickness.			Weight in Lbs. per Lin. Foot.
Inches.	Millimetres.	Parts of an Inch.	Decimals of an Inch.	Millimetres.	
2½	64	¼	0 25	6 34	6 01
2½	64	5/16	0 3125	7 93	7 30
2¾	70	¼	0 25	6 34	6 66
2¾	70	5/16	0 3125	7 93	8 14
3	77	¼	0 25	6 34	7 34
3	77	9/32	0 28125	7 14	8. 17
3	77	5/16	0 3125	7 93	8.97
3	77	⅜	0 375	9.52	10 61
3¼	83	9/32	0 28125	7 14	8 98
3¼	83	⅜	0 375	9 52	11 52
3½	89	9/32	0 28125	7 14	9 69
3½	89	⅜	0 375	9 52	12 52
3¾	95	9/32	0 28125	7 14	10 43
3¾	95	⅜	0 375	9 52	13 52
4	102	5/16	0 3125	7 93	12 31
4	102	7/16	0 4375	11 11	16 66
4¼	108	5/16	0 3125	7 93	13 14
4¼	108	7/16	0 4375	11 11	17 82
4½	115	5/16	0 3125	7 93	13. 98
4½	115	7/16	0 4375	11 11	18 98
4¾	121	5/16	0 3125	7 93	14 01
4¾	121	7/16	0 4375	11 11	20 15
5	127	5/16	0 3125	7 93	15 66
5	127	7/16	0 4375	11 11	21 32
5½	140	5/16	0 3125	7 93	17 32
5½	140	7/16	0 4375	11 11	23 65
5¾	146	⅜	0 375	9 52	21 53
5¾	146	½	0 5	12 69	28 04
6	153	⅜	0 375	9 52	22 53
6	153	13/32	0 40625	10 31	24 29
6	153	½	0 5	12 69	29 37
6	153	9/16	0 5625	14 28	32 67
6¼	159	13/32	0 40625	10 31	25 37
6¼	159	9/16	0 5625	14 28	34 17
6½	166	13/32	0 40625	10 31	26 46
6½	166	9/16	0 5625	14 28	35 67
6¾	171	13/32	0 40625	10 31	27 54
6¾	171	9/16	0 5625	14 28	37 18
7	178	13/32	0 40625	10 31	28 69
7	178	15/32	0 46875	11 90	32 72
7	178	9/16	0 5625	14. 28	38 68
7	178	⅝	0 625	15 87	42 56
7½	191	15/32	0 46875	11 90	36 22
7½	191	⅝	0 625	15 87	45 90
7¾	197	15/32	0 46875	11 90	36 47
7¾	197	⅝	0. 625	15 87	47 57
8	203	15/32	0 46875	11 90	37.73
8	203	⅝	0 625	15 87	49 23
8½	216	15/32	0 46875	11 90	40.23
8½	216	½	0 5	12 69	42 73
8½	216	⅝	0 625	15 87	52 57
8½	216	11/16	0 6875	8 73	57 38
8¾	222	½	0 5	12 69	44 06
8¾	222	11/16	0 6875	8 73	59 21
9	229	½	0 5	12 69	45 40
9	229	11/16	0 6875	8.73	61.04

WEIGHT OF STEEL ANGLES

Sum of Flanges.		Thickness in Deci-									
		0.10	0.12	0.14	0.16	0.18	0.20	0.22	0.24	0.26	0.28
		Thickness in									
Inches.	Millimetres.	2.78	3.18	3.57	3.97	4.76	5.16	5.56	5.95	6.75	7.14
2	51	0.65	0.77	0.89	1.00	1.11	1.22	1.33	1.44	1.54	1.64
2⅛	54	0.69	0.82	0.94	1.07	1.19	1.31	1.42	1.54	1.65	1.76
2¼	57	0.73	0.87	1.00	1.14	1.27	1.39	1.52	1.64	1.76	1.88
2⅜	60	0.77	0.92	1.06	1.20	1.34	1.48	1.61	1.74	1.87	1.99
2½	64	0.82	0.97	1.12	1.27	1.42	1.56	1.71	1.84	1.98	2.11
2⅝	67	0.86	1.02	1.18	1.34	1.50	1.65	1.80	1.95	2.09	2.23
2¾	70	0.90	1.07	1.24	1.41	1.57	1.73	1.89	2.05	2.20	2.35
2⅞	73	0.94	1.12	1.30	1.48	1.65	1.82	1.99	2.15	2.31	2.47
3	77		1.18	1.36	1.54	1.73	1.90	2.08	2.25	2.42	2.59
3⅛	79		1.23	1.42	1.61	1.80	1.99	2.17	2.35	2.53	2.71
3¼	83		1.28	1.48	1.68	1.88	2.07	2.27	2.46	2.64	2.83
3⅜	86		1.33	1.54	1.75	1.96	2.16	2.36	2.56	2.75	2.95
3½	89		1.38	1.60	1.82	2.03	2.24	2.45	2.66	2.86	3.07
3⅝	92		1.43	1.66	1.88	2.11	2.33	2.55	2.76	2.97	3.18
3¾	95		1.48	1.72	1.95	2.18	2.41	2.64	2.86	3.09	3.30
3⅞	98		1.53	1.78	2.02	2.26	2.50	2.73	2.97	3.20	3.43
4	102			1.84	2.09	2.34	2.58	2.83	3.07	3.31	3.54
4¼	108			1.96	2.22	2.49	2.75	3.01	3.27	3.53	3.68
4½	115			2.08	2.36	2.64	2.92	3.20	3.48	3.75	4.02
4¾	121			2.19	2.50	2.80	3.09	3.39	3.68	3.97	4.26
5	127			2.31	2.63	2.95	3.26	3.58	3.88	4.19	4.49
5¼	133				2.77	3.10	3.43	3.76	4.09	4.41	4.73
5½	140				2.90	3.26	3.60	3.95	4.29	4.63	4.97
5¾	146				3.04	3.41	3.77	4.14	4.50	4.85	5.21
6	153					3.56	3.94	4.32	4.70	5.07	5.45
6¼	159					3.71	4.11	4.51	4.90	5.30	5.68
6½	166					3.87	4.28	4.70	5.11	5.52	5.92
6¾	171						4.45	4.88	5.31	5.74	6.16
7	178						4.62	5.07	5.52	5.96	6.40
7¼	184						4.79	5.26	5.72	6.18	6.64
7½	191						4.96	5.45	5.92	6.40	6.87
7¾	197						5.13	5.63	6.13	6.62	7.11
8	203							5.82	6.33	6.84	7.35
8¼	209							6.01	6.54	7.06	7.59
8½	216								6.74	7.28	7.83
8¾	222								6.94	7.51	8.06
9	229									7.73	8.30
9½	242									8.17	8.78
10	254										9.25
10½	267										
11	280										
11½	293										
12	305										
12½	318										

PER FOOT RUN.

MILS OF AN INCH.											
0.30	0 32	0 34	0 36	0 38	0 40	0 42	0 44	0 46	0 48	0 50	0 52
MILLIMETRES.											
7 74	8 14	8 73	9 32	9 72	10 32	10 71	11.31	11.70	12 30	12 70	13 29
1 73	1 83										
1 86	1 96										
1 99	2 10										
2 12	2 24	2 35									
2 24	2 37	2 50									
2 37	2 51	2 64	2 77								
2.50	2 64	2 79	2 93								
2 63	2 78	2 93	3 08	3 22							
2 75	2 92	3 07	3 23	3 39							
2 88	3 05	3 22	3 38	3 55	3 71						
3.01	3 19	3 36	3 54	3 71	3 88						
3 14	3.32	3 51	3 69	3 87	4 05	4 22					
3 26	3.46	3 65	3 84	4 03	4 22	4 40					
3 39	3 60	3 80	4 00	4 19	4 39	4 58	4 76				
3 52	3 73	3 94	4 15	4 35	4 56	4 76	4 95				
3 65	3 87	4.09	4 30	4 52	4 73	4 93	5 14	5 34			
3 77	4 00	4 23	4 46	4 68	4 90	5 11	5 33	5 54			
4 03	4 28	4 52	4 76	5 00	5 24	5 47	5 70	5 93	6 15		
4 28	4 55	4 81	5 07	5 32	5 58	5 83	6 07	6 32	6 56	6 80	7 04
4 54	4 82	5 10	5.37	5 65	5 92	6 18	6 45	6 71	6 97	7 23	7 48
4 79	5 09	5.39	5 68	5 07	6 26	6 54	6 82	7 10	7 38	7 65	7 92
5 06	5 36	5 68	5 99	6 20	6 60	6 90	7 20	7 49	7 78	8 08	8 36
5 30	5 64	5 96	6 29	6 62	6 94	7 25	7 57	7 88	8 19	8 50	8 80
5.56	5 91	6 25	6 60	6 94	7 28	7 61	7 94	8 27	8 60	8 93	9 25
5 81	6 18	6 54	6 90	7 26	7 62	7 97	8 32	8 66	9 01	9 35	9 69
6 07	6 45	6 83	7 21	7 58	7 96	8 33	8 69	9 06	9 42	9 78	10 13
6 32	6 72	7 12	7 52	7 91	8 30	8 68	9 07	9 45	9 82	10 20	10.57
6 58	7 00	7 41	7 82	8 23	8 64	9 04	9 44	9 84	10 23	10 63	11 01
6 83	7 27	7 70	8 13	8 55	8 98	9 40	9 81	10 23	10 64	11 05	11 46
7 09	7 54	7 99	8 43	8 88	9 32	9 75	10 19	10 62	11 05	11 48	11 90
7 34	7 81	8 28	8 74	9 20	9 66	10 11	10 59	11 01	11 46	11 90	12 34
7 60	8 08	8 57	9 05	9 52	10 00	10 47	10 94	11 40	11 86	12 33	12 78
7 85	8 36	8 85	9 35	9 85	10 34	10 82	11 31	11 79	12 27	12 75	13.22
8 11	8 63	9 14	9 66	10 17	10 68	11 18	11 68	12 18	12 68	13 18	13 67
8 36	8 90	9 43	9 96	10 40	11 03	11 54	12 06	12 57	13 09	13 60	14 11
8 62	9 17	9 72	10 27	10 81	11 36	11 90	12 43	12 97	13 50	14 03	14 55
8 87	9 44	10 01	10 58	11 14	11 70	12 25	12 81	13 36	13 90	14 45	14 99
9 38	9 99	10 69	11 19	11 78	12 38	12 97	13 55	14 14	14 72	15 30	15 88
9 89	10.53	11 17	11 80	12 43	13 06	13 68	14 30	14 92	15 54	16 15	16 76
10 40	11 08	11 74	12 41	13 08	13 74	14 39	15 05	15 70	16 35	17 00	17 64
....	11.62	12 32	13 02	13 72	14 42	15 11	15 80	16 48	17 17	17.85	18 53
....		12 90	13 64	14 37	15 10	15 82	16 55	17 27	17 98	18 70	19 41
....	..	....	14.25	15 01	15 78	16 54	17 29	18 05	18 80	19 55	20 30
....	..	....	....	15 66	16 46	17 25	18 04	18 83	19 62	20 40	21.18

WEIGHT OF STEEL ANGLES

Sum of Flanges.		Thickness in Deci-									
		0.54	0.56	0.58	0.60	0.62	0.64	0.66	0.68	0.70	0.72
		Thickness in									
Inches.	Millimetres.	13.69	14.28	14.88	15.27	15.67	16.27	16.86	17.46	17.85	18.45
5	127	8.19									
5¼	133	8.65									
5½	140	9.11	9.41	9.70							
5¾	146	9.57	9.88	10.20							
6	153	10.02	10.36	10.69	11.02						
6¼	159	10.48	10.83	11.18	11.53						
6½	166	10.94	11.31	11.67	12.04	12.40	12.75				
6¾	171	11.40	11.79	12.17	12.55	12.92	13.30				
7	178	11.86	12.26	12.66	13.06	13.45	13.84	14.23			
7¼	184	12.32	12.74	13.15	13.57	13.98	14.38	14.79			
7½	191	12.78	13.21	13.65	14.08	14.50	14.93	15.35	15.77	16.18	
7¾	197	13.24	13.69	14.14	14.59	15.03	15.47	15.91	16.35	16.78	
8	203	13.70	14.17	14.63	15.10	15.56	16.02	16.47	16.92	17.37	17.82
8¼	209	14.16	14.64	15.13	15.61	16.08	16.56	17.03	17.50	17.97	18.43
8½	216	14.61	15.12	15.62	16.12	16.61	17.10	17.59	18.08	18.56	19.05
8¾	222	15.07	15.59	16.11	16.63	17.14	17.65	18.15	18.66	19.16	19.66
9	229	15.53	16.07	16.60	17.14	17.67	18.19	18.71	19.24	19.75	20.27
9½	242	16.45	17.02	17.59	18.16	18.72	19.28	19.84	20.39	20.94	21.49
10	254	17.37	17.97	18.58	19.18	19.77	20.37	20.96	21.55	22.13	22.72
10½	267	18.29	18.93	19.56	20.20	20.83	21.46	22.08	22.70	23.32	23.94
11	280	19.20	19.88	20.55	21.22	21.88	22.54	23.20	23.86	24.51	25.17
11½	293	20.12	20.83	21.53	22.24	22.94	23.63	24.32	25.02	25.70	26.39
12	305	21.04	21.78	22.52	23.26	23.49	24.72	25.45	26.17	26.89	27.61
12½	318	21.96	22.73	23.5[illegible]	24.48	25.04	25.81	26.57	27.33	28.08	28.84
13	331	22.88	23.69	24.49	25.30	26.10	26.90	27.69	28.48	29.27	30.06
13½	343	23.79	24.64	25.48	26.32	27.15	27.98	28.81	29.64	30.46	31.29
14	356	24.71	25.59	26.46	27.34	28.21	29.07	29.93	30.80	31.65	32.51
14½	369	25.63	26.54	27.45	28.36	29.26	30.16	31.06	31.95	32.84	33.73
15	381	26.55	27.49	28.44	29.38	30.31	31.25	32.18	33.11	34.03	34.96
15½	394	27.47	28.45	20.42	30.40	31.37	32.34	33.30	34.26	35.22	36.18
16	407	28.38	29.40	30.41	31.42	32.42	33.42	34.42	35.42	36.41	37.41

		0.10	0.12	0.14	0.16	0.18	0.20	0.22	0.24	0.26	0.28
13	331										
13½	343										
14	356										
14½	369										
15	381										
15½	394										
16	407										

PER FOOT RUN.

MALS OF AN INCH.

0 74	0.76	0.78	0.80	0 82	0 84	0.86	0 88	0 90	0 92	0 94	0 96
MILLIMETRES.											
18 85	19 44	19 84	20 43	20 83	21 43	22 02	22 42	23 01	23 41	24 01	24 40
...	...	...	...		...					...	...
...	...	...									...
...	...	...								...	
...		...			...						
...	...	...	...		...				...		...
...	...	...	...			...					...
...		...	...						...	...	...
...	...	...			...			...	...	...	...
...	...	...			...						...
...	...	...	...								...
...	...	...						...		...	...
...	...		...					...			...
...	...				...						...
...			...					...	...		...
19 52	20 00	...									
20 15	20 65										...
20 78	21 20	21 80	22 30	...							
22 04	22 58	23 13	23 66							...	
23 30	23 88	24 45	25 02	25 50		...			...		...
24 56	25 17	25 78	26 38	26 99							...
25 81	26 46	27 10	27 74	28 38	29 02	...			...	...	
27 07	27 75	28 43	29 10	29 78	30 44						...
28 33	29 04	29 76	30 46	31 17	31 87	32 57	33 27				...
29 59	30 34	31 08	31 82	32 56	33 30	34 04	34 77			...	...
30 85	31 63	32 41	33 18	33 90	34 73	35 50	36 26	37 03	...	...	...
32 10	32 92	33 73	34 54	35 35	36 16	36 96	37 76	38 56			...
33 36	34 21	35 06	35 90	36 75	37 58	38 42	39 26	40 09	40 91	41 74	
34 62	35 51	36 39	37 26	38 14	30 01	39 88	40 75	41 62	42 48	43 34	
35 88	36 81	37 71	38 62	39 53	40 44	41 35	42 25	43 15	44 04	44 04	45 83
37 14	38 10	39 04	30 98	40 93	41 87	42 81	43 74	44 68	45 61	46 53	47 46
38 39	39 38	40 36	41 34	42 32	43 30	44 27	45 24	46 21	47 17	48 13	49 09
0 30	0 32	0 34	0 36	0 38	0 40	0 42	0 44	0 46	0 48	0 50	0 52
...	...				17 14	17 96	18 70	19 61	20 43	21 25	22 06
						18 68	19 54	20 39	21 25	22 10	22 95
...							20 29	21 18	22 06	22 95	23 83
...	...	...						21 96	22 88	23 80	24 72
...	...				...	...	...	...	23 70	24 65	25 60
...	...	...			...		...	...	...	25 50	26 48
...	...	...	...	...	...	...		...	...	...	27 37

WEIGHT IN LBS. OF STEEL BULB ANGLES PER FOOT RUN.

Size.		Thickness in Decimals of an Inch.														
		0 30	0 32	0 34	0 36	0 38	0 40	0 42	0 44	0 46	0 48	0 50	0 52	0 54	0 56	0 58
		Thickness in Millimetres.														
Inches.	Millimetres.	7 74	8 14	8 73	9 32	9 72	10 32	10 71	11 31	11 70	12 30	12 70	13 29	13 89	14 28	14 88
5 ×3	127× 77	9 43	9 89	10 35	10 61	11 27	11 74	12 20	12 66	13 12	13 59	14 05	14 51	14 97	15 44	15 90
5½×3	140× 77	10 12	10 60	11 09	11 57	12 06	12 56	13 03	13 52	14 00	14 49	14 98	15 46	15 95	16 44	16 92
6 ×3	153× 77		11 41	11 92	12 43	12 94	13 45	13 96	14 47	14 98	15 49	16 00	16 51	17 02	17 53	18 04
6½×3	166× 77			12 68	13 22	13 75	14 28	14 82	15 35	15 89	16 42	16 95	17 49	18 02	18 56	19 09
6½×3½	166× 89			13 34	13 91	14 48	15 04	15 61	16 18	16 75	17 31	17 88	18 45	19 02	19 59	20 15
7 ×3	178× 77				14 17	14 73	15 30	15 86	16 43	16 99	17 56	18 12	18 69	19 25	19 81	20 38
7 ×3½	178× 89				14 87	15 46	16 06	16 65	17 25	17 84	18 44	19 03	19 63	20 22	20 82	21 41
7½×3	191× 77					15 76	16 35	16 94	17 53	18 12	18 71	19 31	19 90	20 49	21 08	21 67
7½×3½	191× 89					16 41	17 03	17 65	18 28	18 90	19 52	20 14	20 76	21 39	22 01	22 63
8 ×3	204× 77						17 24	17 86	18 48	19 10	19 72	20 33	20 95	21 57	22 19	22 81
8 ×3½	204× 89						18 02	18 67	19 32	19 97	20 62	21 26	21 91	22 56	23 21	23 86
8½×3	216× 77							18 88	19 53	20 18	20 83	21 48	22 13	22 78	23 43	24 08
8½×3½	216× 89							19 71	20 38	21 06	21 74	22 41	23 09	23 77	24 44	25 12
9 ×3	229× 77								20 71	21 39	22 07	22 75	24 43	24 11	24 76	25 47
9 ×3½	229× 89								21 48	22 18	22 89	23 59	24 29	25 00	25 70	26 41
9½×3½	242× 89									23 27	24 01	24 74	25 48	26 21	26 94	27 68
10 ×3½	254× 89										25 19	25 95	26 71	27 47	28 24	29 00
10½×3½	267× 89										26 46	27 25	28 05	28 84	29 63	30 42
11 ×3½	280× 89											28 38	29 20	30 03	30 85	31 67
11½×3½	293× 89											29 87	30 73	31 58	32 43	33 29
12 ×3½	304× 89												31 92	32 80	33 69	34 57
12 ×4	304×102												32 84	33 75	34 66	35 56

WEIGHT IN LBS. OF STEEL BULB ANGLES PER FOOT RUN.—(*Continued.*)

Size.		Thickness in Decimals of an Inch.														
		0 60	0 62	0 64	0 66	0 68	0 70	0 72	0 74	0.76	0 78	0 80	0 82	0 84	0 86	0 88
		Thickness in Millimetres.														
Inches.	Millimetres.	15 27	15 87	16 27	16 86	17 46	17 85	18 45	18 85	19 44	19 84	20 43	20 83	21 43	22 02	23 42
5 ×3	127× 77	16 63	16 82													
5½×3	140× 77	17 41	17 90													
6 ×3	153× 77	18 55	19 06	19 57												
6½×3	166× 77	19 62	20 16	20 69	21 23											
6½×3½	166× 89	20 72	21 29	21 86	22 43											
7 ×3	178× 77	20 94	21 51	22 07	22 64	23 20										
7 ×3½	178× 89	22 01	22 60	23 20	23 79	24 39										
7½×3	191× 77	22 26	22 85	23 45	24 04	24 63	25 22									
7½×3½	191× 89	23 25	23 88	24 50	25 12	25 74	26 36									
8 ×3	204× 77	23 43	24 05	24 67	25 29	25 90	26 52	27 14								
8 ×3½	204× 89	24 51	25 16	25 81	26 46	27 11	27 76	28 41								
8½×3	216× 77	24 73	25 38	26 02	26 67	27 32	27 97	28 62	29 27							
8½×3½	216× 89	25 80	26 47	27 15	27 82	28 50	29 18	29 85	30 53							
9 ×3	229× 77	26 15	26 83	27 51	28 19	28 87	29 55	30 23	30 91	31 59						
9 ×3½	229× 89	27 11	27 81	28 52	29 22	29 92	30 63	31 33	32 04	32 74						
9½×3½	242× 89	28 41	29 15	29 88	30 62	31 35	32 08	32 82	33 55	34 29	35 02					
10 ×3½	254× 89	29 76	30 52	31 28	32 04	32 80	33 57	34 33	35 09	35.85	36 61	37 37				
10½×3½	267× 89	31 21	32 01	32 80	35 59	34 38	35 18	35 97	36 76	37 55	38 34	39 14				
11 ×3½	280× 89	32 40	33 32	34 14	34 96	35 79	36 61	37 43	28 25	39 08	39 90	40 72	41 54			
11½×3½	293× 89	34 14	34 99	35 85	36 70	37 55	38 41	39 26	40 11	40.97	41 82	42 67	43 53	44 38		
12 ×3½	304× 89	35 45	36 34	37 22	38 11	38 99	39 87	40 76	41 64	42 53	43 41	44 29	45 18	46 06	46 95	
12 ×4	304×102	36 47	37 38	38 29	39.20	40 10	41 01	41.92	42 83	43.73	44 64	45 55	46 46	47.37	48.27	49.19

WEIGHT IN LBS. OF STEEL CHANNELS PER FOOT RUN.

Size.		Thickness in Decimals of an Inch.												
		0 30	0.32	0 34	0 36	0 38	0 40	0 42	0 44	0 46	0 48	0 50	0 52	0 54
		Thickness in Millimetres.												
Inches.	Millimetres.	7 74	8 14	8 73	9 32	9 72	10 32	10 71	11 31	11 70	12.30	12 70	13 29	13 69
6 ×3 ×3	153× 77× 77	14 77	15 18	15 50	16 00	16.41	16 81	17 22	17 63	18 04	18 46	18 85	19 26	19 67
6 ×3½×3½	153× 89× 89	16 30	16 80	17 20	17 61	18.02	18 43	18 84	19 24	19 65	20 06	20 47	20 88	21 28
7 ×3 ×3	178× 77× 77		16 27	16 75	17 22	17 70	18 17	18 65	19 13	19 60	20 08	20 55	21 03	21 51
7 ×3½×3½	178× 89× 89		18 35	18 82	19 30	19 77	20 25	20 73	21 20	21 66	22 15	22 63	23 11	23.58
7½×3 ×3	191× 77× 77			17 70	18 21	18 72	19 23	19 74	20 25	20 76	21 27	21 78	22 29	22 80
7½×3½×3½	191× 89× 89			19 40	19 91	20 42	20 93	21 44	21 95	22 46	22 97	23 46	23 09	24 50
8 ×3 ×3	204× 77× 77				18 82	19 37	19 91	20 45	21 00	21 54	22 09	22 63	23 17	23 72
8 ×3½×3½	204× 89× 89				20 96	21 51	22 05	22 59	23 14	23 68	24 23	24 77	25 31	25 98
8 ×4 ×4	204×102×102				23 30	23 55	24 39	24 94	25 48	26 02	26 57	27 11	27 88	28 20
8½×3 ×3	216× 77× 77					20 37	20 94	21 52	22 10	22 08	23 26	23 83	24 41	24 99
8½×3½×3½	216× 89× 89					22 62	23 20	23 78	24 36	24 94	25 51	26 09	26 67	27 25
9 ×3½×3½	229× 89× 89						23 88	24 49	25 11	25 72	26 33	26 94	27 55	28 17
9 ×4 ×4	229×102×102						26 27	26 88	27 50	28 11	28 72	29 33	29 94	30 56
9½×3½×3½	242× 89× 89						24 56	25 21	25 55	26 60	27 15	27 79	28 44	29 08
10 ×3½×3½	254× 89× 89							26 36	27 04	27 72	28 40	29 08	29 76	30 44
10 ×4 ×4	254×102×102							28 31	28 99	29 67	30 35	31 03	31 71	32 39
10½×3½×3½	267× 89× 89							27 07	27 78	28 50	29 21	29 92	30 64	31 35
11 ×3½×3½	280× 89× 89								28 53	29 28	39 03	30 78	31 53	32 27
11 ×4 ×4	280×102×102								31 00	31 75	32 40	33 24	33 99	34 14
11½×3½×3½	293× 89× 89								29 70	30 46	31 27	32 05	32 83	36 61
12 ×3½×3½	305× 89× 89									31 27	32 00	32 90	33 72	34 53
12 ×4 ×4	305×102×102									33 84	34 66	35 48	36 29	37 11
15 ×4 ×4	381×102×102										39 56	40 58	41 60	42 62

WEIGHT IN LBS. OF STEEL CHANNELS PER FOOT RUN.—(*Continued.*)

Size.		Thickness in Decimals of an Inch.												
		0 56	0 58	0 60	0 62	0 64	0 66	0 68	0 70	0 72	0 74	0 76	0 78	0 80
		Thickness in Millimetres.												
Inches	Millimetres.	14 28	14 88	15 27	15 67	16 27	16 86	17 46	17 65	18 45	18 85	19 44	19 84	20 43
6 ×3 ×3	153× 77× 77	20 08	20 40	20 89	21 30	21 71								
6 ×3½×3½	153× 89× 89	21 69	22 10	22 51	22 92	23 32								
7 ×3 ×3	178× 77× 77	21 98	22 46	22 93	23 41	23 89	24 36							
7 ×3½×3½	178× 89× 89	24 06	24 53	25 01	25 49	25 96	26 44							
7½×3 ×3	191× 77× 77	23 31	23 82	24 33	24 84	25 35	25 86	26 37						
7½×3½×3½	191× 89× 89	25 01	25 52	26 03	26 54	27 05	27 56	28 07						
8 ×3 ×3	204× 77× 77	24 26	24 81	25 35	25 89	26 41	26 98	27 53	28 07					
8× 3½×3½	204× 89× 89	26 40	26 95	27 49	28 03	28 58	29 12	29 67	30 21					
8 ×4 ×4	204×102×102	28 74	29 29	29 83	30 38	30 92	31 46	32 01	32 55					
8½×3 ×3	216× 77× 77	25 55	26 13	26 72	27 30	27 85	28 46	29 04	29 61	30 19				
8½×3½×3½	216× 89× 89	27 83	28 40	28 98	29 56	30 14	30 72	21 29	31 87	32 45				
9 ×3½×3½	220× 89× 89	28 78	29 39	30 00	30 61	31 23	31 84	32 45	33 06	33 67	34 29			
9 ×4 ×4	229×102×102	31 17	31 78	32 39	33 00	33 62	34 23	34 84	35 45	36 06	36 67			
9½×3½×3½	242× 89× 89	29 73	30 36	31 02	31 67	32 31	32 96	33 61	34 25	34 90	35 54			
10 ×3½×3½	254× 89× 89	31 12	31 80	32 48	33 16	33 84	32 52	35 20	35 88	36 56	37 24	37 92		
10 ×4 ×4	254×102×102	33 07	33 75	34 43	35 11	35 79	36 47	37 15	37 83	38 51	39 19	39 87		
10½×3½×3½	267× 89× 89	32 07	32 78	33 49	34 21	34 92	35 64	36 35	37 06	37 78	38 49	39 21		
11 ×3½×3½	280× 89× 89	33 02	33 77	34 52	35 27	36 01	36 76	37 51	38 26	39 01	39 75	40 50	41 25	
11 ×4 ×4	280×102×102	35 49	36 23	36 98	37 73	38 48	39 23	39 97	40 72	41 47	42 22	42 97	43 71	
11½×3½×3½	203× 89× 89	34 39	35 18	35 96	36 74	37 52	38 30	39 09	39 87	40 65	41 43	42 21	43 00	
12 ×3½×3½	305× 89× 89	35 35	36 17	36 98	37 80	38 61	39 43	40 25	41 06	41 88	42 69	43 51	44 33	45 14
12 ×4 ×4	305×102×102	37 92	38 74	39 56	40 37	41 19	42 00	42 82	43 64	44 45	45 27	46 08	46 90	47 72
15 ×4 ×4	381×102×102	43 64	44 66	45 68	46 70	47 72	48 74	49 76	50 78	51 80	52 82	53 84	54 86	55 88

WEIGHT IN LBS. OF STEEL BULB TEES PER FT. RUN.

Size.		Thickness in Decimals of an Inch.							
		0 30	0 32	0 34	0 36	0 38	0 40	0 42	0 44
		Thickness in Millimetres.							
Inches.	Millimetres	7 74	8 14	8 73	9 32	9 72	10 32	10 71	11 31
7×5	178×127	16 13	16 00	17 08	17 55	18 03	18 51	18 98	19 46
8×5½	203×140		19 36	19 90	20 44	20 99	21 53	22 08	22 62
9×5½	229×140			22.79	23 40	24 01	24 62	25 24	25 85
10×6	254×153		...		27 01	27 69	28 37	29 05	29 73
11×6½	280×166		..			31 71	32 46	33 20	33 95
12×6½	305×166						35 58	36 40	37 22

Size.		Thickness in Decimals of an Inch.							
		0 46	0 48	0 50	0 52	0 54	0 56	0 58	0 60
		Thickness in Millimetres.							
Inches.	Millimetres.	11 70	12 30	12 70	13 29	13 89	14 28	14 88	15 27
7×5	178×127	19 93	20 41	20 89	21 36	21 84	22 31		
8×5½	203×140	23 16	23 71	24 25	24 80	25 34	25 88	26 43	26 97
9×5½	229×140	26 46	27 07	27 68	28 30	28 91	29 52	30 13	30 74
10×6	254×153	30 41	31 09	31 77	32 45	33 13	33 81	34 49	35 17
11×6½	280×166	34 70	35 45	36 20	36 94	37 60	38 44	39 19	39 94
12×6½	305×166	38 03	38 85	39 66	40 48	41 30	42 11	42 93	43 74

Size.		Thickness in Decimals of an Inch.							
		0 62	0 64	0.66	0 68	0 70	0 72	0 74	0.76
		Thickness in Millimetres.							
Inches.	Millimetres.	15 87	16 27	16 86	17 46	17 85	18 45	18 85	19 44
7×5	178×127								
8×5½	203×140								
9×5½	229×140	31 36	31 97						
10×6	254×153	35 85	36 53	37 21	37 80				
11×6½	280×166	40 68	41 43	42 18	42 93	43 68	44 42		
12×6½	305×166	44 56	45 48	46 29	47 11	47 92	48 74	49 56	50 37

WEIGHT IN LBS. OF STEEL BULB PLATES PER FT. RUN.

Depth.		Thickness in Decimals of an Inch.										
		0 16	0 18	0 20	0 22	0 24	0 26	0 28	0 30	0 32	0 34	0 36
		Thickness in Millimetres.										
Inches.	Millimetres.	3 97	4 76	5 15	5 56	5,95	6 75	7 14	7 74	8 14	8 73	9,32
5	127	3 79	4 13	4 47	4 81	5.15	5 49	5 83	6 17	6 51	6 85	7 19
6	153			5 54	5 95	6.36	6 77	7 17	7 58	7 99	8 40	8 81
7	178				7 15	7 62	8 10	8 58	9.05	9 55	10 00	10 48
8	204							9 95	10 50	11 04	11 58	12 13
9	229								12 29	12 90	13 52	14 13
10	254									14 48	15 16	15 48
11	280											
12	304											

Depth.		Thickness in Decimals of an Inch.										
		0 38	0 40	0 42	0 44	0 46	0 48	0.50	0 52	0 54	0 56	0 58
		Thickness in Millimetres.										
Inches.	Millimetres.	9 72	10 32	10 71	11 31	11 70	12 30	12 70	13 29	13 89	14 28	14 88
5	127	7 53	7 87									
6	153	9 21	9 62	10 03	10 44							
7	178	10 96	11 43	11 91	12 38	12 86	13 93	13 81				
8	204	12 67	13 22	13 76	14 30	14 85	15 39	15 94	16 48	17 02	17 57	18 11
9	229	14 74	15 35	15 96	16 58	17 19	17 80	18 41	19 02	19 64	20 25	20 86
10	254	16 52	17 20	17 88	18 56	19 24	19 92	20 60	21 28	21 96	22 64	23 32
11	280	18 52	19 27	20 02	20 76	21 51	22 26	23 01	23 76	24 50	25 25	26 00
12	304		21 26	22 07	22 89	23 71	24 52	25 34	26 15	26 97	27 79	28 60

Depth.		Thickness in Decimals of an Inch.									
		0 60	0 62	0 64	0 66	0 68	0 70	0 72	0 74	0.76	0 78
		Thickness in Millimetres.									
Inches.	Millimetres.	15 27	15 87	16 27	16 86	17 46	17 85	18 45	18 85	19 44	19 84
5	127										
6	153										
7	178										
8	204										
9	229	21 47	22 08								
10	254	24 00	24 68	25 36	26 04	26 72					
11	280	26 75	27 50	28 24	28 99	29 74	30 49	31 24	31 98		
12	304	29 42	30 23	31 05	31 87	32 68	33 50	34 31	35 13	35 95	36 78

WEIGHTS OF STEEL ZEE BARS PER FOOT RUN.

Size of Web and Flanges.		Thickness in Decimals of an Inch.						
		0.30	0 32	0 34	0 36	0 38	0 40	0 42
		Thickness in Millimetres.						
Inches.	Millimetres.	7 74	8 14	8 73	9 32	9 72	10 32	10 71
5×3 ×3	127×77×77	12 71	13 30	13 88	14 47	15 05	15 64	16.22
6×3½×3½	153×89×89		15 99	16 68	17 38	18 05	18 74	19.42
7×3½×3½	178×89×89			18 08	18 80	19 51	20 22	20 94
8×3½×3½	204×89×89				20 24	20 99	21 74	22 50
9×3½×3½	229×89×89					22 54	23 34	24 14
10×3½×3½	254×89×89						24 99	25 84

Size of Web and Flanges.		Thickness in Decimals of an Inch.						
		0 44	0 46	0 48	0 50	0 52	0 54	0 56
		Thickness in Millimetres.						
Inches.	Millimetres.	11 31	11 70	12 30	12 70	13 29	13 89	14 28
5×3 ×3	127×77×77	16 81	17 39	17 98	18 56	19 15	19 73	20 32
6×3½×3½	153×89×89	20 11	20 79	21 48	22 16	22 85	23 54	24 22
7×3½×3½	178×89×89	21 65	22 37	23 08	23 79	24 51	25 22	25 94
8×3½×3½	204×89×89	23 25	24 00	24 75	25 50	26 26	27 01	27 76
9×3½×3½	229×89×89	24 93	25 73	26 53	27 33	28 12	28 92	29 72
10×3½×3½	254×89×89	26 88	27 53	28 38	29 22	30 07	30 92	31 76

Size of Web and Flanges.		Thickness in Decimals of an Inch.					
		0 58	0 60	0 62	0 64	0 66	0 68
		Thickness in Millimetres.					
Inches.	Millimetres.	14 88	15 27	15 87	16 27	16.89	17 48
5×3 ×3	127×77×77	20 90	21 49				
6×3½×3½	153×89×89	24 91	25 59	26 28			
7×3½×3½	178×89×89	26 65	27 36	28 08	28 79		
8×3½×3½	204×89×89	28 51	29 26	30 02	30 77	31 52	
9×3½×3½	229×89×89	30 51	31 31	32 11	32 90	33 70	34 50
10×3½×3½	254×89×89	32 61	33 46	34 30	35.15	35 09	36 84

WEIGHT OF A SQUARE FOOT IN LBS, AND AREA IN FEET PER TON OF STEEL PLATING.

Thickness.			Weight per Square Foot in Lbs.	Number of Square Feet per Ton.
Fractions of an Inch.	Decimals of an Inch.	Millimetres.		
$\frac{1}{50}$	0.02	0.50799	0.816	2745.098
$\frac{2}{50}$	0.04	1.01598	1.632	1372.549
$\frac{3}{50}$	0.06	1.52397	2.448	915.033
$\frac{4}{50}$	0.08	2.03196	3.264	686.275
$\frac{5}{50}$	0.10	2.53995	4.08	549.02
$\frac{6}{50}$	0.12	3.04794	4.896	457.516
$\frac{7}{50}$	0.14	3.55594	5.712	392.157
$\frac{8}{50}$	0.16	4.06393	6.528	343.137
$\frac{9}{50}$	0.18	4.57192	7.344	305.011
$\frac{10}{50}$	0.20	5.07991	8.16	274.51
$\frac{11}{50}$	0.22	5.58790	8.976	249.554
$\frac{12}{50}$	0.24	6.09589	9.792	228.758
$\frac{13}{50}$	0.26	6.60388	10.608	211.161
$\frac{14}{50}$	0.28	7.11187	11.424	196.078
$\frac{15}{50}$	0.30	7.61986	12.24	183.007
$\frac{16}{50}$	0.32	8.12785	13.056	171.569
$\frac{17}{50}$	0.34	8.63584	13.872	161.476
$\frac{18}{50}$	0.36	9.14383	14.688	152.505
$\frac{19}{50}$	0.38	9.65183	15.504	144.479
$\frac{20}{50}$	0.40	10.15982	16.32	137.255
$\frac{21}{50}$	0.42	10.66781	17.136	130.719
$\frac{22}{50}$	0.44	11.17580	17.952	124.777
$\frac{23}{50}$	0.46	11.68379	18.768	119.352
$\frac{24}{50}$	0.48	12.19178	19.584	114.379
$\frac{25}{50}$	0.50	12.69977	20.4	109.804
$\frac{26}{50}$	0.52	13.20776	21.216	105.581
$\frac{27}{50}$	0.54	13.71575	22.032	101.670
$\frac{28}{50}$	0.56	14.22374	22.848	98.039
$\frac{29}{50}$	0.58	14.73173	23.664	96.659
$\frac{30}{50}$	0.60	15.23972	24.48	91.503
$\frac{31}{50}$	0.62	15.74772	25.296	88.552
$\frac{32}{50}$	0.64	16.25571	26.112	85.784
$\frac{33}{50}$	0.66	16.76370	26.928	83.185
$\frac{34}{50}$	0.68	17.27169	27.744	80.738
$\frac{35}{50}$	0.70	17.77968	28.56	78.431
$\frac{36}{50}$	0.72	18.28767	29.376	76.253
$\frac{37}{50}$	0.74	18.79566	30.192	74.192
$\frac{38}{50}$	0.76	19.30365	31.008	72.239
$\frac{39}{50}$	0.78	19.81164	31.824	70.387
$\frac{40}{50}$	0.80	20.31903	32.64	68.627
$\frac{41}{50}$	0.82	20.82762	33.456	66.954
$\frac{42}{50}$	0.84	21.33561	34.272	65.359
$\frac{43}{50}$	0.86	21.84361	35.088	63.839
$\frac{44}{50}$	0.88	22.35160	35.904	62.389
$\frac{45}{50}$	0.90	22.85959	36.72	61.002
$\frac{46}{50}$	0.92	23.36758	37.536	59.676
$\frac{47}{50}$	0.94	23.87557	38.352	58.406
$\frac{48}{50}$	0.96	24.38356	39.168	57.190
$\frac{49}{50}$	0.98	24.89155	39.984	56.022
1	1.00	25.39954	40.8	54.902

WEIGHTS OF BUILT STEEL TUBULAR PILLARS.

Outside Diameter.		Thickness.		Weight per Foot Run, Lbs.
Inches.	Millimetres.	Inches.	Millimetres.	
6	153	0.40	10.32	23.93
6½	166	0.40	10.32	26.06
7	178	0.40	10.32	28.20
7½	191	0.40	10.32	30.34
8	203	0.40	10.32	32.47
8	203	0.44	11.31	35.53
8½	216	0.40	10.32	34.61
8½	216	0.44	11.31	37.88
9	229	0.40	10.32	36.74
9	229	0.44	11.31	40.23
10	254	0.40	10.32	41.02
10	254	0.44	11.31	44.93
10	254	0.50	12.70	50.74
11	280	0.44	11.31	49.63
11	280	0.50	12.70	56.08
12	305	0.50	12.70	61.42
12	305	0.54	13.89	66.10
13	331	0.54	13.89	71.87
13	331	0.60	15.27	79.47
14	356	0.54	13.89	77.64
14	356	0.60	15.27	85.88
15	381	0.60	15.27	92.29
16	407	0.60	15.27	98.70
17	432	0.60	15.27	105.11
18	458	0.60	15.27	111.51
18	458	0.64	16.27	118.68
18	458	0.70	17.85	129.35
18	458	0.74	18.85	136.43

WEIGHT PER SQUARE FOOT IN LBS. AND AREA IN FEET PER TON OF ARMOR

Thickness.			Weight per Square Foot in Lbs.			Area in Feet per Ton.		
Inches.	Decimals of a Foot.	Millimetres.	490 Lbs. per Cubic Foot.	495 Lbs. per Cubic Foot.	500 Lbs. per Cubic Foot.	490 Lbs. per Cubic Foot.	495 Lbs. per Cubic Foot.	500 Lbs. per Cubic Foot.
3	0.25	76.1986	122.50	123.75	125.00	18.29	18.10	17.92
3½	0.2917	88.8984	142.92	144.38	145.83	15.67	15.51	15.36
4	0.3333	101.5982	163.33	165.00	166.67	13.72	13.58	13.44
4½	0.375	114.2979	183.75	185.63	187.50	12.19	12.07	11.95
5	0.4167	126.9977	204.17	206.25	208.33	10.97	10.86	10.75
5½	0.4583	139.6975	224.58	226.88	229.17	9.97	9.87	9.77
6	0.5	152.3973	245.00	247.50	250.00	9.14	9.05	8.96
6½	0.5417	165.0970	265.42	268.13	270.83	8.44	8.35	8.27
7	0.5833	177.7968	285.85	288.75	291.67	7.82	7.76	7.68
7½	0.625	190.4966	306.25	309.38	312.50	7.31	7.24	7.17
8	0.6667	203.1963	326.67	330.00	333.33	6.86	6.79	6.72
8½	0.7083	215.8961	347.08	350.63	354.17	6.45	6.39	6.33
9	0.75	228.5959	367.50	371.25	375.00	6.10	6.03	5.97
10	0.8333	253.9954	408.33	412.50	416.67	5.49	5.43	5.38
11	0.9167	279.3950	449.17	453.75	458.33	4.99	4.94	4.89
12	1.0	304.7945	490.00	495.00	500.00	4.57	4.53	4.48
13	1.0833	330.1940	530.83	536.25	541.67	4.22	4.18	4.14
14	1.1667	355.5936	571.67	577.50	583.33	3.91	3.88	3.84
15	1.25	380.9931	612.50	618.75	625.00	3.66	3.62	3.58
16	1.3333	406.3927	653.33	660.00	666.67	3.43	3.40	3.36
17	1.4167	431.7922	694.17	701.25	708.33	3.23	3.19	3.16
18	1.5	457.1917	735.00	742.50	750.00	3.05	3.02	2.99
19	1.5833	482.5913	775.83	783.75	791.67	2.89	2.86	2.83
20	1.6667	507.9908	816.67	825.00	833.33	2.75	2.72	2.69
21	1.75	533.3804	857.50	866.25	875.00	2.61	2.59	2.56
22	1.8333	558.7899	898.33	907.50	916.67	2.50	2.47	2.45
23	1.9167	584.1894	939.17	948.75	958.33	2.39	2.36	2.34
24	2.0	609.5890	980.00	990.00	1000.00	2.29	2.26	2.24

WEIGHTS AND AREAS OF PUNCHINGS OF CIRCULAR LIGHTENING AND OTHER HOLES FROM STEEL PLATING OF VARIOUS THICKNESSES.

Diameter of Punchings.		Area, Square Inches.	Thickness in Decimals of an Inch.								
			0.24	0 26	0 28	0 30	0 32	0 34	0 36	0 38	0 40
			Thickness in Millimetres.								
Inches.	Millimetres.		5 95	6 75	7 14	7 74	8 14	8 73	9 32	9 72	10 32
3	77	7.07	0 48	0 52	0.56	0 60	0 64	0 68	0 72	0 76	0 80
4	102	12 57	0 85	0 93	1 00	1 07	1 14	1 21	1 28	1 35	1 42
5	127	19 64	1 34	1 45	1 56	1 67	1 78	1 89	2 00	2 11	2 23
6	153	28 27	1 92	2 08	2 24	2 40	2 56	2 72	2 88	3 04	3 20
7	178	38 48	2 62	2 83	3 05	3 27	3 49	3 71	3 93	4 14	4 36
8	203	50 27	3 42	3 70	3 99	4 27	4 56	4 84	5 13	5 41	5 70
9	229	63 62	4 33	4 69	5 05	5 41	5 77	6 13	6 49	6 85	7 21
10	254	78 54	5 34	5 79	6 23	6 68	7 12	7 57	8 01	8 46	8 90
11	280	95 03	6 46	7 00	7.54	8 08	8 62	9 15	9 69	10 23	10 77
12	305	113 10	7 69	8 33	8 97	9 61	10 25	10 89	11 54	12 18	12 82
13	331	132 73	9 03	9 78	10 53	11 28	12 03	12 79	13 54	14 29	15 04
14	356	153 94	10 47	11 34	12 21	13 08	13 96	14 83	15 70	16 57	17 45
15	381	176 71	12 02	13 02	14 02	15 02	16 02	17 02	18 03	19 03	20 03
16	407	201 06	13 67	14 81	15 95	17 09	18 23	19 37	20 51	21 65	22 79
17	432	226 98	15 44	16 72	18 01	19 29	20 58	21 87	23 15	24 44	25 72
18	457	254 47	17 30	18 75	20 19	21 63	23 07	24 51	25 96	27 40	28 84

Diameter of Punchings.		Area, Square Inches.	Thickness in Decimals of an Inch.								
			0 42	0 44	0 46	0 48	0 50	0 52	0 54	0 56	0 58
			Thickness in Millimetres.								
Inches.	Millimetres.		10 71	11 31	11 70	12 30	12 70	13 29	13 89	14 28	14 88
3	77	7 07	0 84	0 88	0 92	0 96	1 00	1 04	1 08	1 12	1 16
4	102	12 57	1 50	1 57	1 64	1 71	1 78	1 85	1 92	1 99	2 06
5	127	19 64	2 34	2 45	2 56	2 67	2 78	2 89	3 00	3 12	3 23
6	153	28 27	3 36	3 52	3 69	3 85	4 01	4 17	4 33	4 49	4 65
7	178	38 48	4 58	4 80	5 02	5 23	5 45	5 67	5 89	6 11	6 32
8	203	50 27	5 98	6 27	6 55	6 84	7 12	7 41	7 69	7 97	8 26
9	229	63 62	7 57	7 93	8 29	8 65	9 01	9 37	9 73	10 09	10 45
10	254	78 54	9 35	9 79	10 24	10 68	11 13	11 57	11 02	11 46	11 91
11	280	95 03	11 31	11 85	12 39	12 92	13 46	14 00	14 54	15 08	15 62
12	305	113 10	13 46	14 10	14 72	15 38	16 02	16 66	17 30	17 94	18 58
13	331	132 73	15 79	16 55	17 30	18 05	18 80	19 55	20 31	21 06	21 81
14	356	153 94	18 32	19 19	20 06	20 93	21 81	22 68	23 55	24 42	25 30
15	381	176 71	21 03	22 03	23 03	24 03	25 04	26 04	27 04	28 04	29 04
16	407	201 06	23 92	25 06	26 20	27 34	28 48	29 62	30 76	31 90	33 04
17	432	226 98	27 01	28 30	29 38	30 87	32 15	33 44	34 73	36 01	37 30
18	457	254 47	30 28	31 72	33 16	34 61	36 05	37 49	38 93	40 37	41 81

Lloyd's Bulb Sections.

The depth in inches D of the section to be the base from which to deduce the other dimensions.

The width of the bulbs to be $2\frac{1}{2}C$ for bulb angles, and $3\frac{1}{4}C$ for bulb plates and tees, when C is $\frac{D+3}{20}$ in the case of bulb angles, and $\frac{D+1}{20}$ for bulb plates and tees. The form of the bulbs to be in accordance with the sketches.

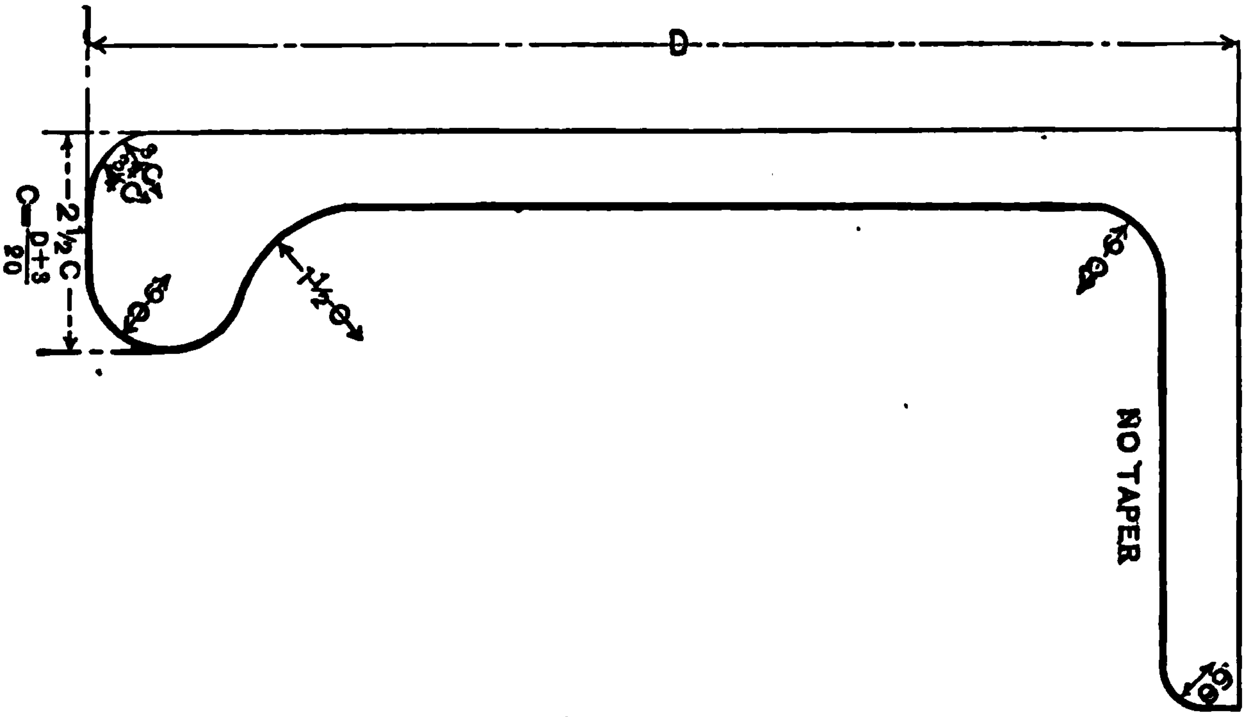


FIG. 44.

The standard thickness for regulating the widths of bulb of beams and bars whose depth is not an exact number of inches, should correspond to the depth in inches next below the actual depth, thus — for tee beams and bulb plates $10\frac{1}{2}$ inches depth, the standard thickness to be used in determining the dimensions of the bulb should be $\frac{10+1}{20}$ or $\frac{11}{20}$. See figures 44 and 45.

C.G. BY EXPERIMENT.

All finished vessels should be inclined before leaving the builder's hands and their exact centre of gravity found experimentally. The value of this information cannot be over-estimated, although in many cases where possessed it does not seem to be applied with the care its importance demands, as evidenced by the proportions of many ships of the merchant marine.

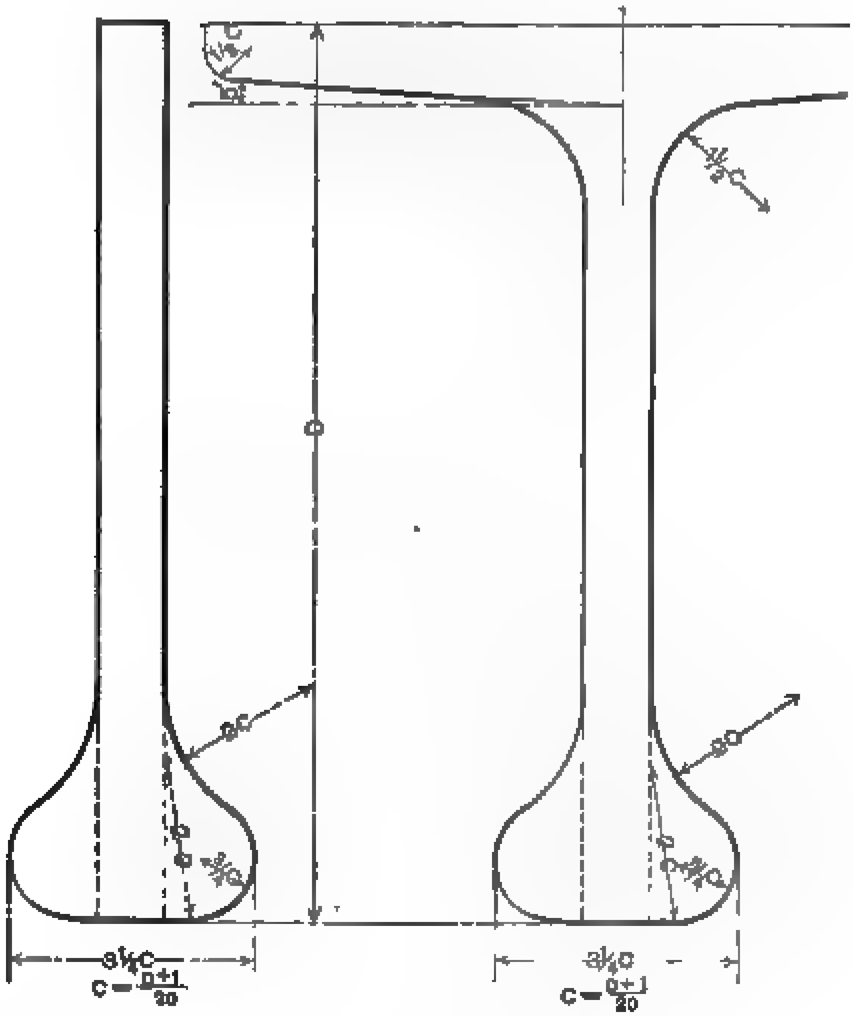


FIG. 45.

The principle on which the experiment is based will be understood from a reference to Fig. 46, where p is a small weight placed on deck at centre line, and afterwards shifted to either side through a distance a. The centre of gravity before the movement was made is shown at G. It will be evident that this centre after the weight has been shifted, will move to a new location parallel to the line of shift, and that the weight multiplied by the distance through which it has been moved, will give a moment equal to the weight of the whole ship by the distance the common centre of gravity G has been moved to G_1, so that we get :—

$$GG_1 = \frac{p \times a}{D}.$$

Before attempting to carry out the inclining experiment, the

following preparations should be made, observing that although not imperative that the vessel be completely finished, it is well to have her in that condition if possible. The bilges should be carefully examined to see that they are perfectly free from loose water, and the boilers, condenser, fresh water and ballast tanks must be either *empty* or pumped up "chock full," as any free water in the ship will destroy the value of the experiment. All workmen, unless those assisting, must be sent ashore, and when the shift is being measured the assistants and laborers should be lined up on centre line of ship, a position they shall have occupied before beginning. The weather should be perfectly calm, and an enclosed space of water as a basin, or dock, selected, and the mooring lines eased off slack to permit the vessel to move freely.

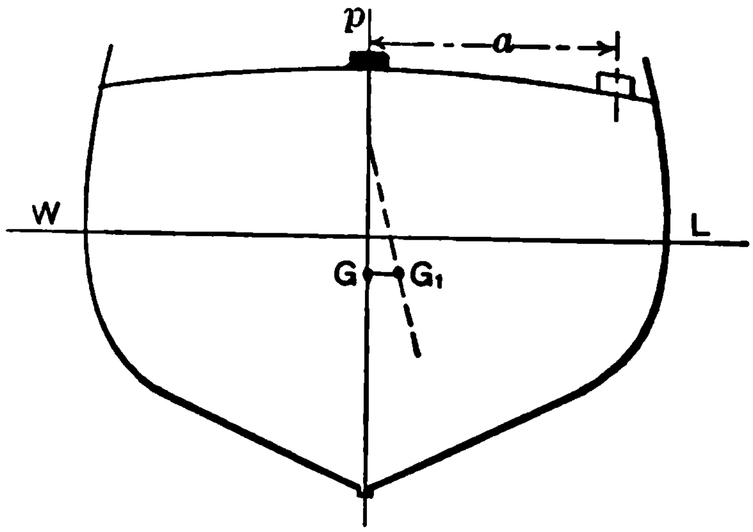


Fig. 46.

The inclining weights should aggregate .5 to one per cent of the displacement, and two parallel lines should be marked off on deck amidships, representing the distance through which the centres of gravity of the weights shall be moved. A suitable position must be obtained, say in the engine or boiler hatch, in which to fix a large tee square with the cross head placed downwards, and a plumb line and bob attached at the end of the blade, care being taken that the bob swings clear of the square. When these preparations have been made and the inclining weights placed on deck, an accurate draught should be taken and the men ranged up on centre line, when a plumb line may be marked off on the edge of square as a starting point, the weights being thereafter transferred from the centre line to port or starboard and an observation made. The weights should then be moved right over to the opposite side, and the inclination noted. As a final check on the total shift the weights may be shifted back to their original position, when of course the plumb line should cover the point originally marked on starting. From the following data procured we shall be enabled to calculate the centre of gravity on the principle previously referred to, viz.: —

(1) Draught of water.
(2) Displacement from the foregoing.

(3) Weights shifted.
(4) Distance between the two lines representing the space through which weights were shifted.
(5) Length of plumb line from point of suspension to edge of square.
(6) Travel of plumb line from port to starboard, and starboard to port. Take *mean.*
(7) Condition of the ship as regards state of completion and what weights as cargo, coal, fresh water, water in boilers, ballast tanks and dunnage are on board.

As the vessel has been previously slacked off, on shifting the weights, it will be apparent that the ship will heel over so that the centre of gravity G, and the centre of buoyancy B_1 (Fig. 47), will be in the same vertical line and M will be the metacentre. Let a represent the angle of heel, then :—

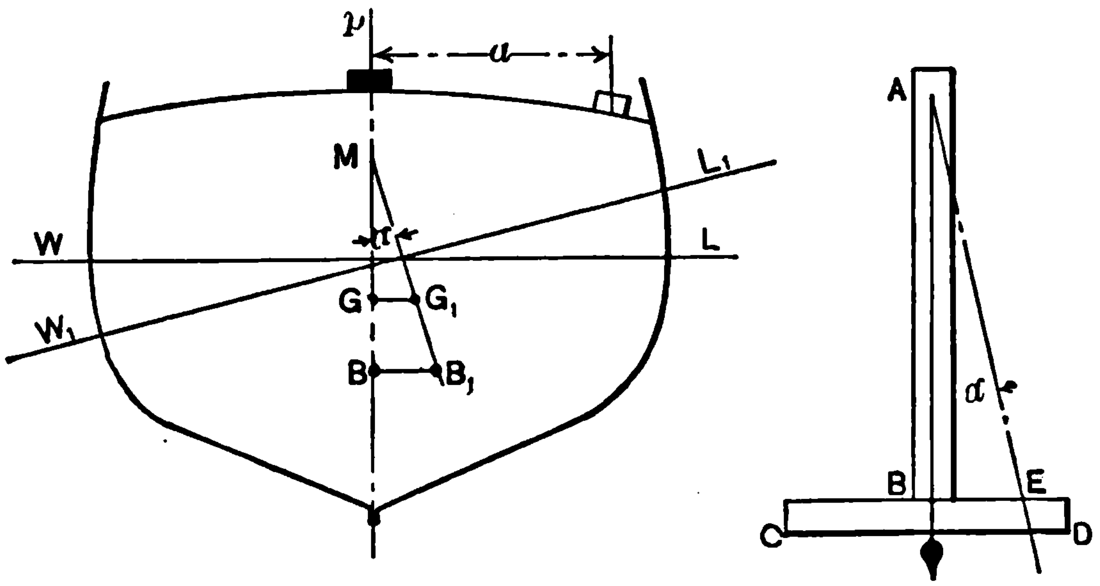


FIG. 47.

The tangent of a is found by taking the length of plumb line "AB" and the mean shift of bob "BE" on tee square, from which we get:—

$$\tan a = \frac{BE}{AB}.$$

The triangle GMG and BAE are similar, then

$$\frac{GG_1}{GM} = \frac{BE}{AB},$$

$$GG_1 = \frac{GM \times BE}{AB} = \frac{P \times a}{D},$$

and
$$GM = \frac{p \times a}{D} \times \frac{AB}{BE} = \frac{p \times a}{D \times \tan a}.$$

The height of M may be calculated for the draught with which we are dealing or directly measured from the metacentric diagram, and the GM as obtained above deducted from this height will give the centre of gravity above base at the time of the experiment. This height of course will require correction by deducting the inclining weights and the excess water in boilers, if these have been pumped chock full for the experiment.

Centre of Gravity.

The vertical centre of gravity of a ship is probably the most important point which the naval architect has to determine, as well as the most difficult to calculate with *accuracy*. Therefore it is that the calculation of this centre in detail is only resorted to when insufficient data derived from a somewhat similar type is wanting, as the most reliable method is that computed from actual centres obtained from experiments. However, where this is not obtainable, the calculation in detail by careful working out and good judgment should give equally accurate results. Where the former method is resorted to, the table of coefficients given in the chapter on Design will be found of service, observing that these are for the finished vessel loaded with a homogeneous cargo.

When, however, it is imperative to go into the calculation in detail, the simplest method will be to treat the hull proper as a shell of uniform thickness, and when the centre of gravity as such is ascertained, to make the necessary additions for excesses on particular strakes, keelsons, beams, deck plating, superstructure and wood, outfit and equipment weights. The centre of gravity of the machinery with steam up will be furnished by the engineers.

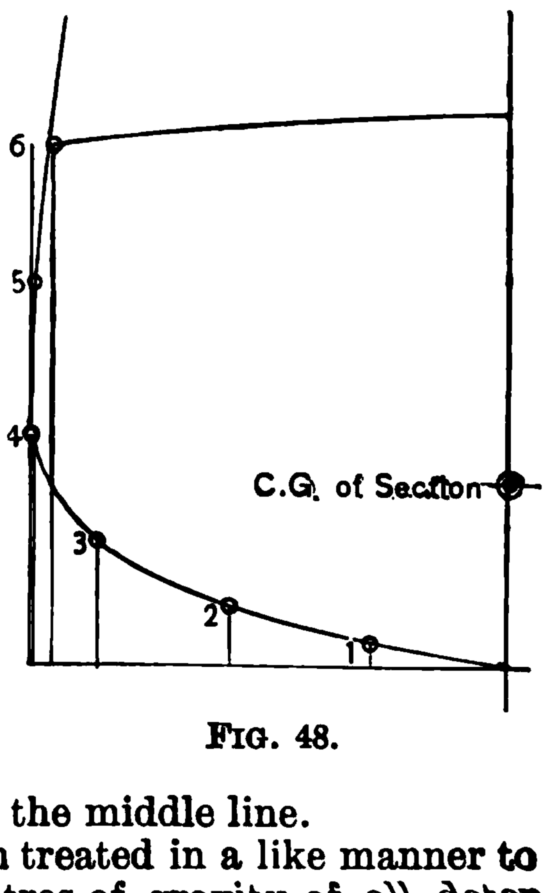


Fig. 48.

On a body plan of ten sections with half-end ordinates, mark off around the half girths of each section a spot every two feet apart, as shown on Fig. 48, dropping a perpendicular line from these locations to the base. Measure these heights above the base and tabulate them for each section, calling the centre line "O" as in the table. One side only need be dealt with, as the ship is symmetrical about the middle line.

Each of the ten sections having been treated in a like manner to the foregoing, and the individual centres of gravity of all deter-

Station.	Section No. 5.		
	Heights.	Multipliers.	Functions.
0	...	½	...
1	.6′	2	1.2
2	1.3′	1	1.3
3	2.4′	2	4.8
4	4.1′	1	4.1
5	6.1′	2	12.2
6	8.2′	½	4.1
...	...	9	)27.7
			3.07′
3.07′ = C.G. of No. 5 above base.			

mined, these centres are then tabulated and the common centre of gravity found by a similar operation to the above, *i.e.*, they are integrated by Simpson's multipliers, and the sum of the functions so obtained divided by the sum of the multipliers, when the resulting quotient will be the perpendicular height of the common centre of gravity of all the sections or of a shell of uniform thickness.

Vertical Centre of Gravity of Shell.

Sections.	C.G. of Sections above Base.	Simpson's Multipliers.	Functions.
0	6.00	¼	1.50
½	5.21	1	5.21
1	4.16	¾	3.12
2	3.50	2	7.00
3	3.36	1	3.36
4	3.20	2	6.40
5	3.07	1	3.07
6	3.56	2	7.12
7	3.93	1	3.93
8	4.20	2	8.40
9	4.66	¾	3.49
9½	5.00	1	5.00
10	5.74	¼	1.43
...	...	15	)59.03
			3.94′
3.94′ = Mean C.G. above base.			

Another method to obtain the vertical height of C.G. due to form for a shell of uniform thickness is to take the sum of the functions of water line half-breadths of all sections from base to gunwale, and divide them by the sum of the multipliers used, which will give a mean half-breadth for each water plane. By plotting off these mean dimensions, a *mean section* of the ship may be drawn on stout paper, cut out with a penknife, then pinned to port and starboard alternately and swung on a board having a plumb line scribed on as shown in Fig. 49.

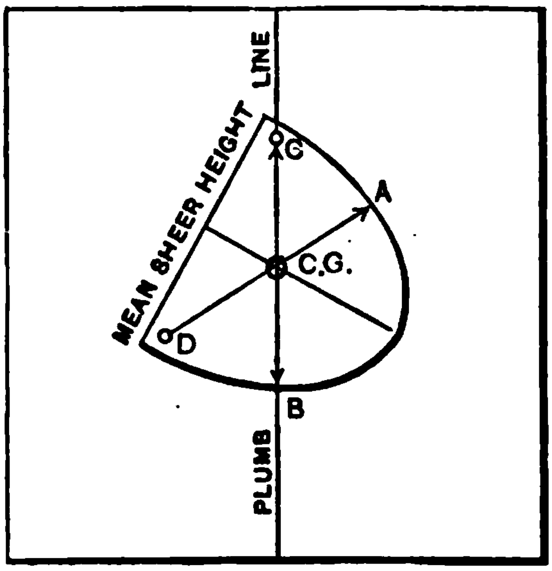


Fig. 49.

The intersection of the mark points *A* and *B* with the plumb line, should be joined with the pin holes *C* and *D*, and where they cross each other on centre line will be the mean height of centre of gravity. Carefully done, this will give a very close approximation to the calculation. Of course the usual additions as mentioned in the preceding method will be required to calculate the actual C.G. of vessel.

Outfit in detail, stores, fresh water, coal, etc., will be set down, giving the weight and estimated height of their respective centres of gravity from base, when the sum of the moments produced divided by the total weight will give a resulting quotient equal to the mean height of C.G. of ship from base without cargo, the centre of gravity of which may be found by a similar experiment, as it is customary to treat this as being of a homogeneous character.

CHAPTER VII.

STRENGTH OF SHIPS.

It is not generally considered necessary to make strength calculations for an ordinary merchant vessel when the scantlings are in accordance with any of the classification societies' rules, but in the case of a special design, and also in warships, it is advisable to do so.

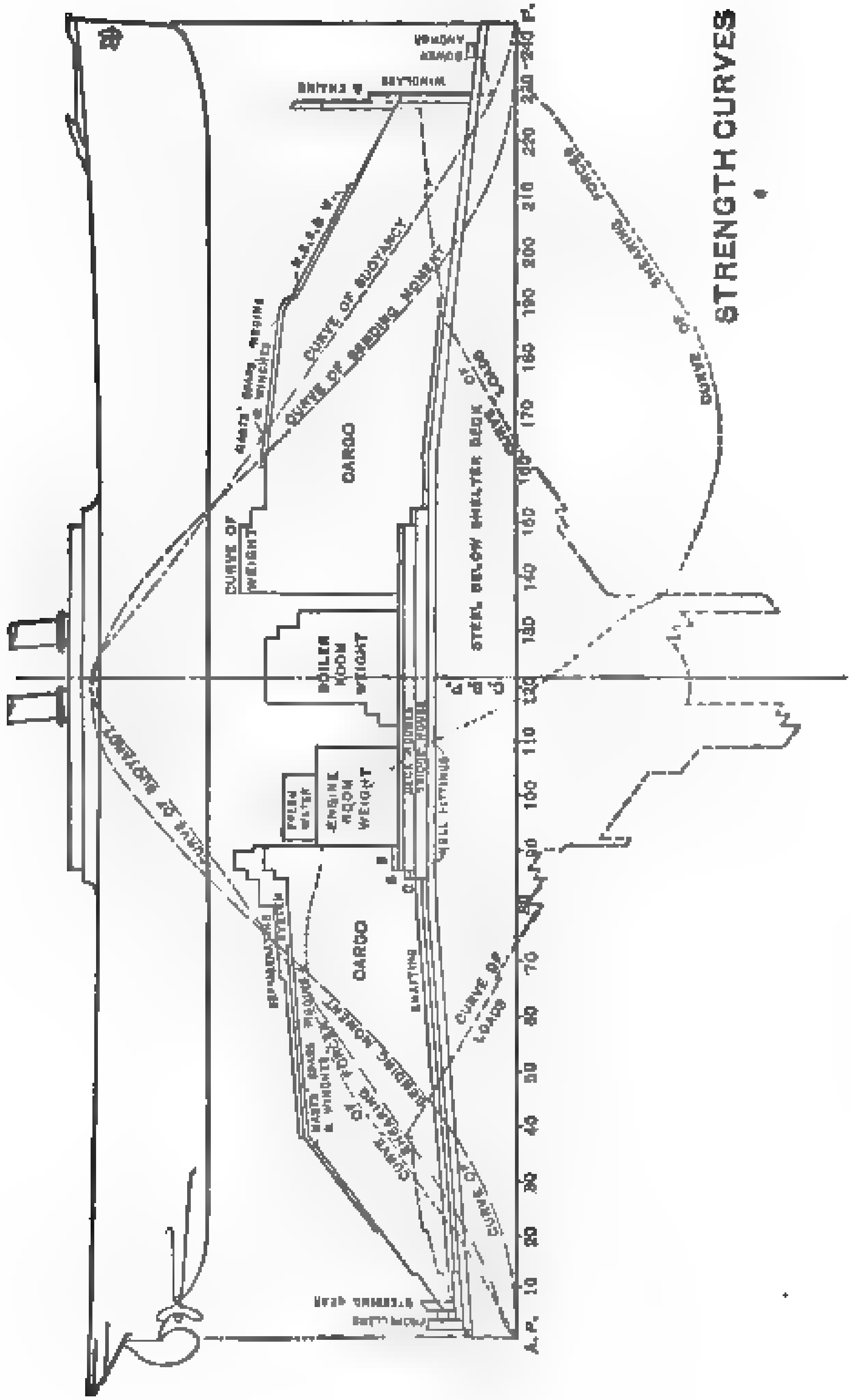
In these calculations, the ship is considered as a girder and the principle is the same as that of a beam supported at both ends, or only at the middle, as may be the case for "sagging" or "hogging" respectively, uniformly loaded but unevenly distributed. As it is practically impossible to determine accurately the amount of stress that a ship will be subjected to when laboring in a seaway, it would seem quite legitimate to arrive at the necessary conclusions on the basis of comparison with other ships, which have proved to be sufficiently strong, and this is what is usually done in practice. In order that this information may be of use for comparative purposes, it is advisable to lay off the curves of weight, buoyancy, bending moments, etc., to some standard length and the mean weight or buoyancy ordinate to some standard height, so as to make the diagram as convenient as possible.

Curve of Weights.

The mean weight per foot of length of the total hull is calculated at convenient distances apart and these set up as ordinates from the base line of the diagram, at their corresponding stations, taking care to use the proper scale as previously determined on; the other heavy weights, as guns, armor, machinery, coal, homogeneous cargo, etc., are calculated separately and added as rectangles above the curve of hull weights. A mean curve is then run through these points, taking care that its centre of gravity comes over the centre of buoyancy and that the area circumscribed by the curve equals the displacement of the ship.

Curve of Buoyancy.

The displacement in tons per foot of length is then calculated at suitable intervals apart and set up as ordinates in the same manner as for the weight curve. The area enclosed by a curve passing through these spots should also equal the displacement of the vessel and will show the distribution of the support given by the fluid pressures in relation to the curve of weights at any point in the ship's length.



STRENGTH CURVES
CURVE OF BUOYANCY
CURVE OF BENDING MOMENT
CURVE OF WEIGHT
CARGO
BOILER ROOM WEIGHT
ENGINE ROOM WEIGHT
FRESH WATER
STEEL BELOW SHELTER DECK
SHAFTING
CURVE OF LOADS
C. B. P.
A. P.
F. P.

FIG. 50.

Calculation Table for

Moment of Inertia of Section			
Item.	**Size.**	Gross Area.	Net Area = A.
		Sq. In.	Sq. In.
Bar keel (½)	6″ × 3″	18.0	14.3
Flat plate keel (½)	27″ × $\frac{23}{20}$″	31.1	22.1
Garboard strake *A*	48″ – $\frac{20}{20}$″	48.0	38.0
Strakes *B*, *C*, *D*, and *E*	4 – 51″ × $\frac{17}{20}$″	173.4	139.4
Strake *F*	48″ × $\frac{18}{20}$″	432	35.1
Strake *G*	60″ × $\frac{18}{20}$″	540	43.2
Strake *H*	54″ × $\frac{18}{20}$″	48.6	38.7
Strake *J*	60″ × $\frac{18}{20}$″	54.0	43.2
Strake *K*	54″ × $\frac{18}{20}$″	48.6	38.7
Strakes *M*, *N*, *O*, *P*, and *R*	5 (54″ × $\frac{17}{20}$″)	229.5	183.0
Strakes *S* and *T*	2 (44″ × $\frac{18}{20}$″)	97.2	174
Strake *U* (sheer)	51″ × $\frac{20}{20}$″ 37.5″ × $\frac{20}{20}$″	51.0 37.5	69.5
Strake *W*	51¾″ × $\frac{20}{20}$″	51.7	40.7
Strake *X* (sheer)	51″ × $\frac{20}{20}$″ 37.5″ × $\frac{20}{20}$″	51.0 37.5	69.5
Strakes *Y* and *Z*	2 – 51″ × $\frac{10}{20}$″	51.0	40.6
℄ Keelson (½)	58″ × $\frac{15}{20}$″	21.7	18.0
℄ Keelson, bottom angle	5″ × 5″ × $\frac{16}{20}$″	7.4	5.6
℄ Keelson, top angle	4″ × 4″ × $\frac{13}{20}$″	4.8	3.5
First longitudinal	47″ × $\frac{10}{20}$″	23.5	4.5
Second longitudinal	44″ × $\frac{10}{20}$″	22.0	4.5
Third longitudinal	40½″ × $\frac{10}{20}$″	20.2	4.5
Margin plate	58″ × $\frac{14}{20}$″	40.6	30.1
Margin angle	4″ × 4″ × $\frac{10}{20}$″	4.8	3.5
Inner bottom strake *A* (½)	30″ × $\frac{13}{20}$″	19.5	16.1
Inner bottom strakes, *B*, *C*, *D*, *E*, *F*	279.5″ × $\frac{11}{20}$″	153.7	131.2
Tie plate	33″ × $\frac{12}{20}$″	19.8	15.6
Bilge keel angles	2 – 6″ × 4″ × $\frac{10}{20}$″	9.5	7.6
Bilge keel plate	10″ × $\frac{12}{20}$″	9.0	8.5
Lower hold stringer	2 [10″ × 3½″ × 48″ 10″ × $\frac{12}{20}$″	21.6	19.6

Moment of Inertia.

AT FRAME *M* AND AT FRAME *N*.						
Arm $= d$.	Moment $= dA$.	Moment of Inertia $= d^2A$	Depth of Web $= h =$ Ft.	Square of Depth $= h^2$.	$\frac{1}{12}$ Net Area $= \frac{A}{12}$	$\frac{1}{12} Ah^2$.
Ft.	Ft. Sq. In.	Ft.^{2} Sq.In.		Ft.^{2}	Sq. In.	Ft.^{2}Sq.In.
- 26.71	−382	10,202	...	....	...	...
− 26 59	−588	15,625	...	....	...	...
− 26.30	−499	26,285	...	....	...	...
- 25.55	−3,562	91,000	...	....	...	...
− 24.60	−863	21,241	...	....	...	...
− 24.00	−1,067	24,883	...	....	...	...
− 22.05	−853	18,816	3	9	3.2	[redacted]
− 18.65	−806	15,026	4.50	20.3	3.6	73
− 14.45	−559	8,081	4.50	20.3	3.2	65
− 2.75	−503	1,383	20.50	420.25	15.25	6,409
11.30	875	9,883	8.5	72.25	6.45	466
17.10	1,188	20,322	{ 4.25 { 3.12	18 06 9.73	3.3 } 2.5 }	84
20.75	845	17,524	4.30	18.49	3.4	63
24.50	1,703	41,717	{ 4.25 { 3.12	18.06 9.73	3.8 } 2.5 }	84
30.10	1,222	36,784	8.00	64.00	3.4	218
− 24.10	− 434	10,454	4.83	23.33	1.5	35
− 26.35	−148	3,888	...	....	...	...
− 21.75	− 76	1,656	...	....	...	...
23 70	−107	2,528	3 92	15.37	.4	6
− 23.25	−105	2,433	3.67	13.47	.4	6
− 22 80	−103	2,339	3.37	11 36	.4	5
- 22.00	·662	14,568	3 67	13.47	2 5	3 4
− 24.10	−84	2,033	...	....	...	...
− 21.55	− 347	7,477	...	....	...	...
− 21.05	−2,762	58,135	...	....	..	...
· 20 33	−317	6,447	...	...	...	...
− 22 60	−172	3,882	...	....	...	...
− 23.00	−196	4,496	...	....	...	...
− 15.60	−306	4,771	..	....	...	...

Calculation Table for Moment

Moment of Inertia of Section			
Item.	Size.	Gross Area.	Net Area = A.
		Sq. In.	Sq. In.
Upper hold stringer	2 [$10'' \times 3\frac{1}{2}'' \times 48''$ $10'' \times \frac{12}{20}''$	21.6	19.6
Orlop deck stringer	$49'' \times \frac{13}{20}''$	31.9	27.9
Orlop deck stringer angle . .	$4'' \times 4'' \times \frac{11}{20}''$	4.1	3.1
Orlop deck plating	$229'' \times \frac{7}{20}''$	80.2	69.7
Lower deck stringer . . .	$49'' \times \frac{13}{20}''$	31.9	27.9
Lower deck stringer angle .	$4'' \times 4'' \times \frac{11}{20}''$	4.1	3.1
Lower deck plating	$229'' \times \frac{8}{20}''$	91.6	79.6
Lower deck ridge bar . . .	$9'' \times 3.85'' \times \frac{10}{20}''$ [	7.9	7.0
Middle deck stringer . . .	$49'' \times \frac{16}{20}''$	39.2	33.6
Middle deck stringer angle .	$4'' \times 4'' \times \frac{11}{20}''$	4.1	3.1
Middle deck plating . . .	$233'' \times \frac{9}{20}''$	104.9	91.4
Middle deck ridge bar . . .	$9'' \times 3.85'' \times \frac{10}{20}''$ [	7.9	7.0
Upper deck stringer . .	$41'' \times \frac{20}{20}''$ $50'' \times \frac{18}{20}''$	41.0 45.0	72.9
Upper deck stringer angle .	$5'' \times 5'' \times \frac{12}{20}''$	5.6	4.3
Upper deck plating . . .	$139'' \times \frac{11}{20}''$ $60'' \times \frac{13}{20}''$	115.5	101.1
Upper deck ridge bar . . .	$8'' \times 3\frac{1}{2}'' \times \frac{10}{20}''$ [	7.0	6.1
Shelter deck stringer . .	$50'' \times \frac{18}{20}''$ $94'' \times \frac{16}{20}''$	45.0 75.2	102.7
Shelter deck stringer angle .	$2 - 5'' \times 5'' \times \frac{10}{20}''$	16.4	12.4
Shelter deck plating . .	$135'' \times \frac{13}{20}''$ $58'' \times \frac{15}{20}''$	131.3	114.3
Shelter deck ridge bar . . .	$8'' \times 3\frac{1}{2}'' \times \frac{10}{20}''$ [	7.0	6.1
Bridge deck stringer . . .	$52'' \times \frac{9}{20}''$	23.4	20.0
Bridge deck stringer angles	$7'' \times 3\frac{1}{2}'' \times \frac{12}{20}''$ $3\frac{1}{2}'' \times 3\frac{1}{2}'' \times \frac{8}{20}''$	8.6	7.3
Bridge deck plating	$246'' \times \frac{5}{20}''$	61.5	50.5
. . . .	. . . . . .	2,515.3	2,036.9
. . . .	. . . . . .	. . .	. . .
. . . .	. . . . . .	2,370.8	1,918.5
. . . .	. . . . . .	. . .	. . .

Moment of Inertia of Section at Frame M.

Assumed neutral axis 26.5′ above base.
Actual neutral axis $= \frac{2613}{2037} = 1.28'$ above assumed neutral axis $= 27.78'$ above base line.
Moment of inertia about correct neutral axis $= 2\,(810{,}320 + 7{,}577 - 3{,}341) = 1{,}629{,}112$ Ft.^{2} Sq. In.

Note.—Rivets neglected both in compression and tension.

of Inertia. — (*Continued.*)

AT FRAME *M* AND AT FRAME *N*.

Arm $= d$.	Moment $= dA$.	Moment of Inertia $= d^2A$.	Depth of Web $= h$ Ft.	Square of Depth $= h^2$.	$\frac{1}{12}$ Net Area $= \frac{A}{12}$.	$\frac{1}{12} Ah^2$.
Ft.	Ft. Sq. In.	Ft.^{2} Sq. In.		Ft.^{2}	Sq. In.	Ft.^{2} Sq. In.
− 11.35	−222	2,524	. . .	. . . .	. . .	. . .
− 6.40	−179	1,144	. . .	. . . .	. . .	. . .
− 6.35	−20	125	. . .	. . . .	. . .	. . .
− 6.00	−418	2,509	. . .	. . . .	. . .	. . .
1.00	45	71	. . .	. . . .	. . .	. . .
1.70	5	9	. . .	. . . .	. . .	. . .
2.00	159	318	. . .	. . . .	. . .	. . .
1.25	9	11	. . .	. . . .	. . .	. . .
9.67	325	3,142	. . .	. . . .	. . .	. . .
9.75	30	295	. . .	. . . .	. . .	. . .
10.00	914	9,140	. . .	. . . .	. . .	. . .
9.25	65	599	. . .	. . . .	. . .	. . .
17.70	1,290	22,840	. . .	. . . .	. . .	. . .
17.70	76	1,347	. . .	. . . .	. . .	. . .
18.10	1,830	33,120	. . .	. . . .	. . .	. . .
17.15	105	1,794	. . .	. . . .	. . .	. . .
25.75	2,645	68,096	. . .	. . . .	. . .	. . .
25.60	317	8,127	. . .	. . . .	. . .	. . .
26.10	2,983	77,861	. . .	. . . .	. . .	. . .
25.15	153	38.58	. . .	. . . .	. . .	. . .
33.65	673	22,646	. . .	. . . .	. . .	. . .
33.75	246	8,315	. . .	. . . .	. . .	. . .
34.05	1,720	58,550	. . .	. . . .	. . .	. . .
. . . .	$\begin{Bmatrix} +19,423 \\ -16,010 \end{Bmatrix}$	810,320	. . .	. . . .	. . .	7,577
. . . .	2,613	. . . .	2,037 ×	$1.28^2 = 3,341$	. . .	. . .
. . . .	$\begin{Bmatrix} +15,562 \\ -16,810 \end{Bmatrix}$	684,025	. . .	. . . .	. . .	7,359
. . . .	−1,248	. . . .	1,919 ×	$.65^2 = 806$	. . .	. . .

MOMENT OF INERTIA OF SECTION AT FRAME *N*.

Assumed neutral axis $=$ 26.5′ above base.

Actual neutral axis $= \frac{1248}{1919} =$ .65′ below assumed neutral axis $=$ 25.85′ above base line.

Moment of inertia about correct neutral axis $=$ 2 (684,025 + 7,359 − 806), $=$ 1,381,156 *Ft.*^{2} *Sq. In.*

Curve of Load.

The curve of loads is obtained by measuring the difference between the curves of weight and buoyancy at the various ordinates and spotting off the excess buoyancy above the base; and the excess weight below their points of intersection with this line will show the waterborne sections, which for calculating purposes are taken as the points of support.

Curve of Shearing Stresses.

This curve is calculated from the foregoing curve of load by taking its area at various ordinates measured from forward aft and plotting these areas off above or below the base line as in the case of the curve of loads, observing that the greatest stresses will be opposite the points of support (or waterborne sections). A curve run through the foregoing spots will show the shearing stresses graphically.

Curve of Bending Moments.

As the bending moment at any section in the length of a ship is equal to the algebraic sum of the shearing stresses in relation to either end, it is evident that a curve of bending moments may be obtained from these stresses and plotted off as was done for the shearing curve from the curve of loads, observing that the maximum and minimum bending moments will be coincident with the points of support.

To apply similar curves and the data constituting them to the determination of the stresses experienced by a ship amongst waves, it is usual to take the two extreme bending moments to which a vessel is subjected, viz.: (1) hogging on the crest of a wave, and (2) sagging in the trough, and to construct a trochoid wave of such form as will give the same displacement of immersed body (in both cases) as obtained in smooth water. The curves are then calculated as explained in the foregoing, taking the height of wave as being $\frac{1}{20}$ of the length.

The subjoined table shows a specimen calculation of the moment of inertia of the sections, observing that although the rivets in this case are neglected for compression, it would probably be somewhat more accurate to include them.

Unless in exceptional cases it will be found sufficiently approximative for comparative purposes to multiply the displacement of the proposed vessel by one-thirtieth to one thirty-fifth of the length when the product will equal the maximum bending moment, as

$$\frac{L \times D}{35} = \text{maximum bending moment},$$

and the minimum tension on sheerstrake equals

$$\frac{\text{Maximum bending moment} \times \text{Neutral axis below sheerstrake}}{\text{Total moment of inertia}} =$$

Tension stress per square inch. The compression on the bottom plating is similarly computed, substituting the distance of neutral axis *above keel* for "below sheerstrake."

The value of the maximum tensile strength per square inch of section varies of course with the size and proportions of vessels. A suitable value for vessels of wholesome proportions built to any of the great classification societies' rules is about 2 tons per square inch in small vessels to about 9 in the largest liners, taking the comparative method of calculating the bending moment given above.

It will be evident from an examination of the table showing a specimen calculation of the moment of inertia of a ship's cross section, that the further the sectional area of the ship is arranged from the neutral axis, the greater will be the moment of resistance to bending. It is in recognition of this geometrical quality that the upper deck in 3-deck and other ships is made the strength deck, and that the keel plate and garboards are thickened as well as the sheerstrake and stringer being increased at that level, in addition to reinforcing the bilge; for, with a ship rolling and pitching, it must often happen that the greatest bending moments will frequently be exerted at the bilge and upper deck gunwale. By making the shelter deck in 3-deck vessels the "strength deck," a great increase in the strength of these ships has been made in recent years, as demonstrated by actual practice, steamers of this class being now practically "4-deckers" from a strength point of view.

CHAPTER VIII.

RESISTANCE OF SHIPS.

The Admiralty Coefficient.

THE amount of power required to propel a vessel at a given speed is generally computed by (1) the Admiralty Coefficient formula, or (2) a formula based on the ship's actual resistance, the former being purely empirical and requiring great judgment and practice in the selection of the coefficient, and the other founded on scientific experimental data and theories which have acquired confirmatory proof amounting to law, since they were first enunciated by William Froude. The following notes on resistance are taken principally from the papers by this eminent investigator, and from the later work of Middendorf, Taylor, and others.

The Admiralty Coefficient (C) is calculated from the results of actual trials, and is based on the false assumptions that the area of wetted surface (S) for similar ships is proportional to the $\frac{2}{3}$ power of the displacement ($D^{\frac{2}{3}}$), and that the resistance (R) plus the propulsive coefficient $\left(\frac{\text{E.H.P.}}{\text{I.H.P.}}\right)$ varies as the cube of the speed (V^3). From this we get the well-known formula:

$$\text{I.H.P.} = \frac{D^{\frac{2}{3}} \times V^3}{C},$$

and for the speed with a stated I.H.P.,

$$V^3 = \frac{C \times \text{I.H.P.}}{D^{\frac{2}{3}}}.$$

Therefore the coefficient:

$$C = \frac{D^{\frac{2}{3}} \times V^3}{\text{I.H.P.}}.$$

It will be obvious that these coefficients must cover a wide range of values, hence the difficulty of their application by the inexperienced. For this reason we append a table of values in vessels of greatly divergent types. It should, however, be noted that for vessels of similar form but different lengths, the coefficient will show great disparity, and for vessels of similar form and length but different draught, there will likewise be much dissimilarity in the coefficient. In the selection of this coefficient it should also

be remembered that the class of steamer to which it is applied must be similar not only in form, but in type of engine as well, and of *corresponding speed*. This does not necessarily mean the *same* speed, as will be explained later.

Table of Admiralty Coefficients.

Type of Vessel.	Length L.	Block Coefficient, δ.	Speed, V.	Admiralty Coefficient, C.
	Feet.		Knots.	
Launches (yachts)	18–30	.28–.38	7 –10	65–70
Launches (navy)	27–45	.30–.40	7 –12	50–70
Vedettes (high speed) . . .	50–60	.35–.42	14 –20	75–130
Speed launches and yachts .	70–100	.41–.43	16 –22	135–165
Steam yachts (large) . . .	130–250	.40–.48	12 –20	165–175
Torpedo boats	100–150	.40–.44	20 –25	140–170
Torpedo boat destroyers . .	170–235	.40–.43	27 –33	175–210
Cruisers	500	.54	22	275
Harbor and revenue steamers	55-75	.45–.50	9 –10	110–120
River steamers (shallow dr.) .	60–100	.50–.55	$8\frac{1}{2}$–13	85–120
River steamers (paddle) . .	100-250	.50–.60	13 –20	100–180
River steamers (stern wheel).	75–150	.65–.75	$8\frac{1}{8}$–13	65–120
Channel steamers	250–300	.58–.65	17 –21	240–270
Freighters (small)	100–250	.73–.78	$8\frac{1}{2}$–11	100–230
Freighters (large)	300–500	.78–.78	11 –13	240–280
Intermediate liners	500–600	.70–.72	14 –16	270–310
Ocean liners	500–750	.60–.65	20 –25	265–285

FROUDE'S LAW OF COMPARISON.

As the result of experiments with models and full sized ships Froude discovered that there was great resemblance between their "curves of resistance," *i.e.*, a curve plotted off with a scale of knots as abscissæ, and the pounds resistance to towing as ordinates. See Fig. 51.

To test this, however, it is necessary to apply the Law of Comparison, which he thus states:—

"If the ship be D times the dimension of the model and at the speeds V_1, V_2, V_3 . . . the measured resistances of the model

are R_1, R_2, R_3 . . ., then for speed $\sqrt{DV_1}$, $\sqrt{DV_2}$, $\sqrt{DV_3}$ . . . of the ship, the resistance will be D^3R_1, D^3R_2, D^3R_3. . . ."

To the speeds of model and ship thus related, he applied the term "corresponding speeds." This law expresses the resistance due to surface friction, plus wavemaking resistance, the former being commonly referred to as skin resistance and the other as residuary resistance, embracing as it does, the resistance caused

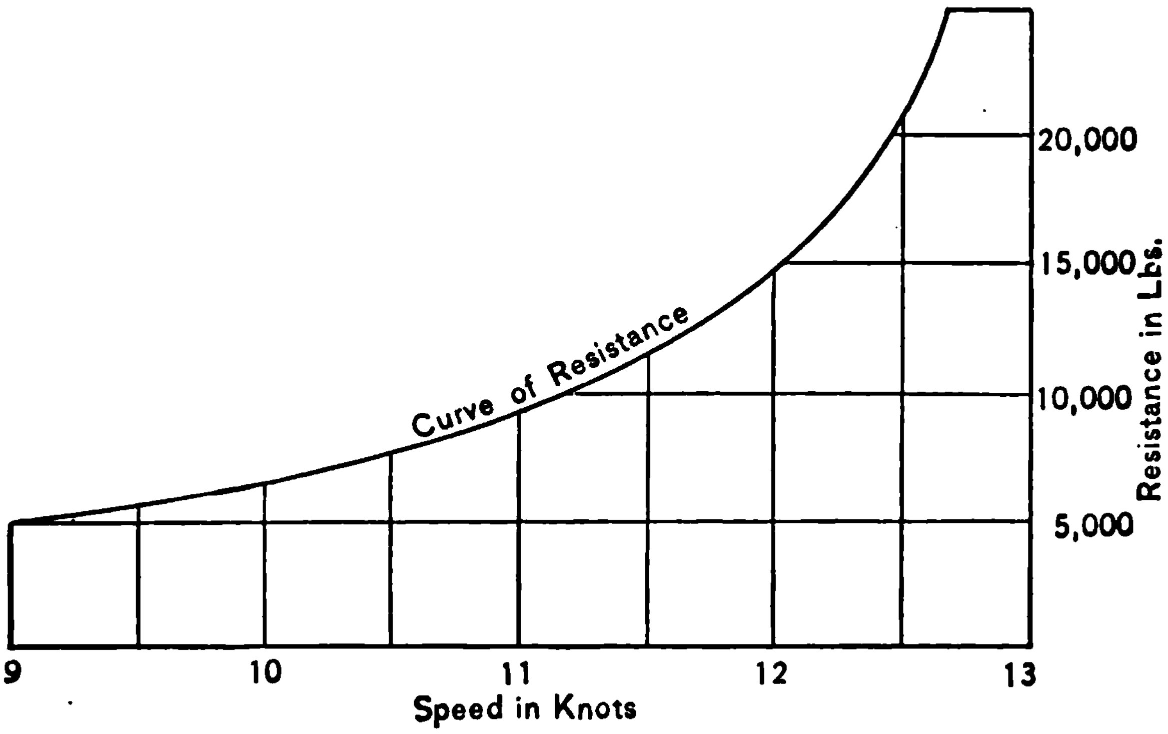


FIG. 51.

by the motion of the waves and the drag of dead water eddies, such as are formed at abrupt endings to bossings, the siding of stern posts and in the wake of propeller struts. The skin resistance is proportional to the area of wetted surface, and is responsible for almost the total resistance up to about 8 knots speed. Beyond this speed the total resistance increases rapidly, showing the effect of the residuary resistance. This will be more readily understood, when we recollect that the wave undulations progressively increase in height with increases in speed, and that the crests of these waves are accountable for about 95 per cent of the total residuary resistance, the remaining 5 per cent, as already stated, being due to eddies, etc. Referring to the diagram here reproduced, showing curves of residuary and skin resistances, "the graduated undulations in the residuary resistance curve are due to quasi-hydrostatic pressure against the after-body, corresponding with the variations in its position with reference to the phases of the train of waves comprising the wave line profile, there being a comparative excess of pressure (causing a forward force or diminution

of resistance) when the after-body is opposite a crest, and the reverse when it is opposite a trough. Their spacing is uniform at a uniform speed, because waves of given speed have always the same length; it is more open at the higher speeds, because waves are longer the higher their speed; their amplitude is greater at

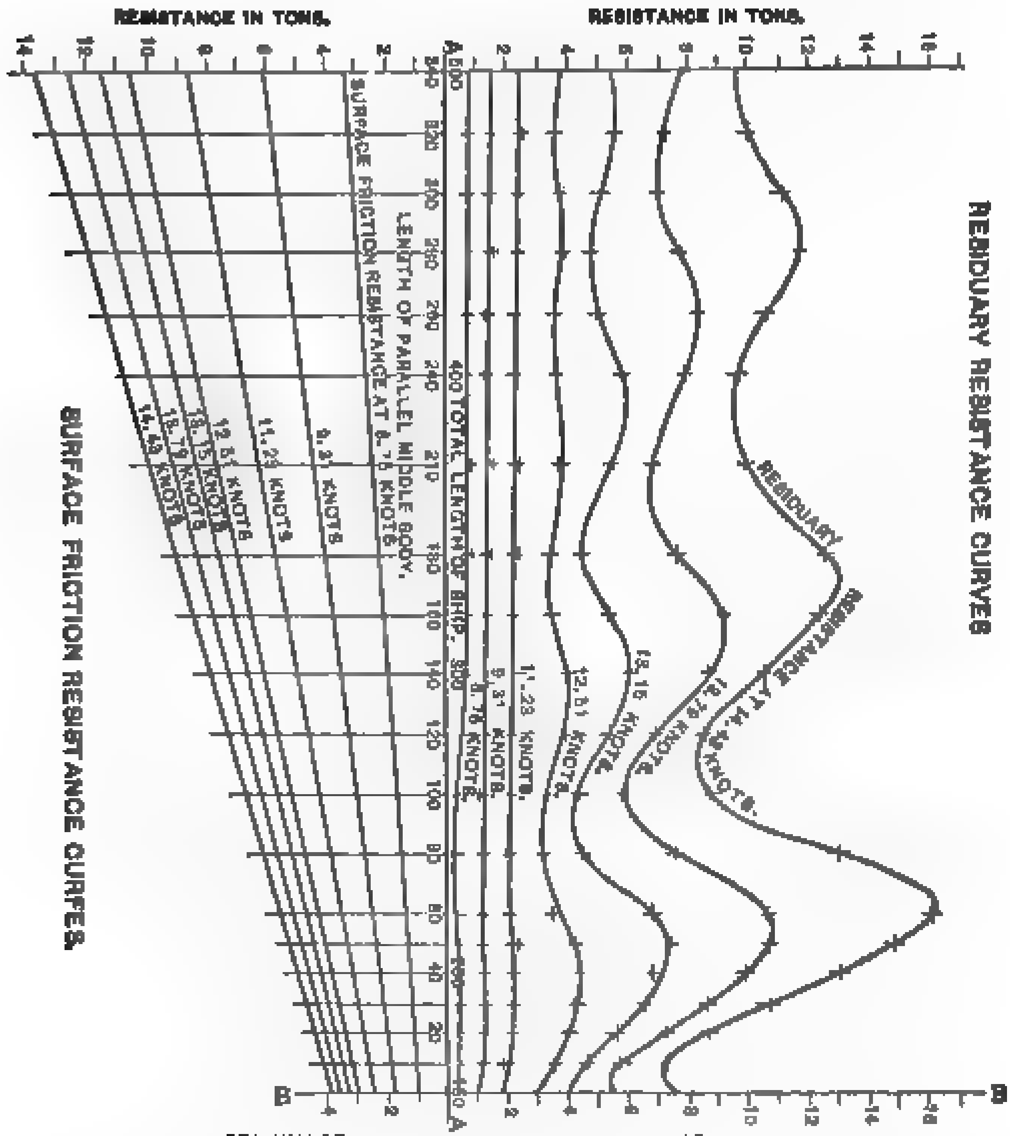


Fig. 52.

the higher speeds, because the waves made by the ship are higher; and their amplitude diminishes with increased length of middle body, because the wave system by diffusing itself transversely loses its height."

Froude found that, at the lower speeds, two ships, one 200 ft. and the other 240 ft. in length, had the same residuary resistance; the difference in the larger vessel was simply due to its increase of skin friction due to the greater wetted surface. At 13.15 knots, however, the 240-foot vessel had the lesser total resistance of the two, owing to her position on the residuary resistance curve coming in a hollow; the consequent diminution in this resistance was greater than her increase of skin friction.

The resistance depends on the relative placing of the after-body and the wave system, and the length spacing of the wave system depends on the speed, therefore the position of after-bodies, which is specially favorable at some given speed, may be specially unfavorable at a higher speed, and at a higher speed still may be favorable again.

This it is which explains the economy with which some vessels attain certain speed whilst others of almost identical form, but slight variation in length, fall short of the others' performance.

To apply the investigations of Froude to actual ships, it is usual to make a model of the proposed ship and run it in a tank, and from the data obtained apply the law of comparison. For example, if a model be made of a liner 700 feet long on a scale of $\frac{1}{8}$ inch to the foot, and the required speed of the ship be 24 knots, at what speed will the model require to be run to correspond with the desired velocity? "*In comparing similar ships, or ships with models, the speed must be proportional to the square root of their linear dimensions.*"

Therefore the model will be

$$\frac{700 \text{ feet}}{\frac{1}{8} \text{ inch}} = 87\tfrac{1}{2} \text{ inches,}$$

or 7 feet $3\frac{1}{2}$ inches, and the ratio of linear dimensions,

$$\frac{700 \text{ feet}}{7.29} = 96,$$

and speed corresponding to 24 knots,

$$24 \div \sqrt{96} = 2.45 \text{ knots.}$$

In like manner, if we are working from the known speed of another ship, say, of 600 feet length, then:

$$\tfrac{700}{600} = 1.16 \text{ ratio of linear dimensions,}$$

and $$24 \div \sqrt{1.16} = 25.8 \text{ knots,}$$

corresponding speed of the 600-foot boat.

APPLICATION OF FROUDE'S LAW.

It is, however, in dealing with data derived from trial performances that the law of comparison is invaluable to those having the

responsibility of powering ships. For, given the trial data of the ships, we may apply this to other vessels of similar form to obtain the I.H.P. necessary to drive them at a stated speed. Of course, we assume that the efficiency of the engines, boilers and propellers are equal in both cases, otherwise that their coefficients of efficiency are the same. So that when we know the displacement, power, and speed of a given ship represented by D, P, and V, and it is required to estimate the I.H.P. from a proposed vessel of like form of D_1, P_1, and V_1, then,

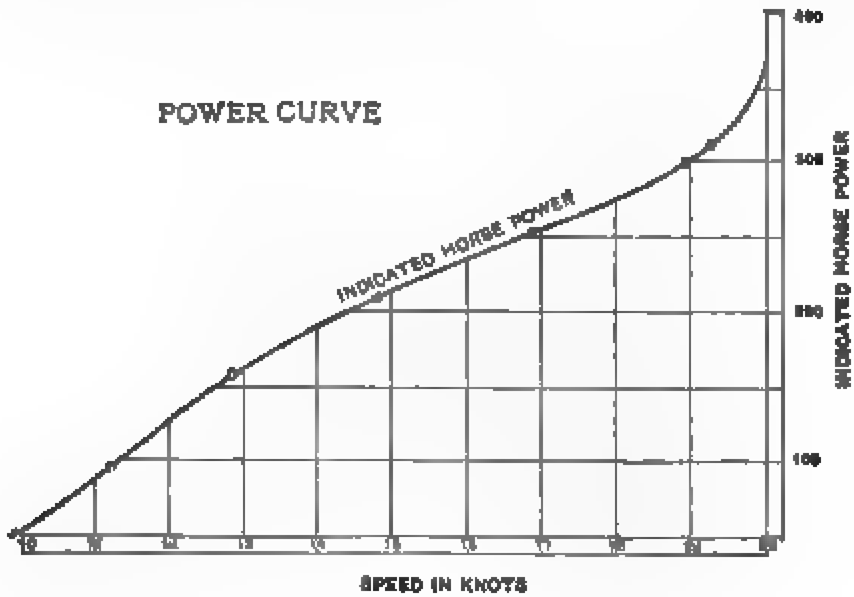


FIG. 53.

$$(1) \qquad P_1 = \left(\frac{D_1}{D}\right)^{\frac{7}{6}} P,$$

and

$$(2) \qquad V_1 = \left(\frac{D_1}{D}\right)^{\frac{1}{6}} V.$$

Substituting values,

$$(1) \qquad P_1 = \left(\frac{32{,}000}{17{,}878}\right)^{\frac{7}{6}} \times 29{,}246$$
$$= 58{,}000 \text{ I.H.P.}$$

$$(2) \qquad V_1 = \left(\frac{32{,}000}{17{,}878}\right)^{\frac{1}{6}} \times 22.1$$
$$= 24.4 \text{ knots.}$$

We may also run a speed curve of the known vessel, where progressive runs have been made, as shown in Fig. 53, and from this deduce the proposed vessel's corresponding curve with the aid of the formula given.

The curve illustrated is that of a 56-ft. vedette pinnace, and it is proposed to deduce the power curve of a 21 knot speed launch from it, being a type of similar form.

Displacement of vedette.	13.75 tons.
Displacement of speed launch . .	22.50 tons.

The corresponding length L_1 of the speed launch would be obtained from the length of the vedette and the ratio of the displacements.

$$\left(\frac{D_1}{D}\right)^{\frac{1}{3}} \times L = \left(\frac{22.50}{13.75}\right)^{\frac{1}{3}} \times 56 \text{ feet} = 66 \text{ feet.}$$

Corresponding speed,

$$\left(\frac{D_1}{D}\right)^{\frac{1}{6}} \quad V = \left(\frac{22.50}{13.75}\right)^{\frac{1}{6}} \times 19.25 = 20.85 \text{ knots.}$$

Corresponding power,

$$\left(\frac{D_1}{D}\right)^{\frac{7}{6}} \quad P = \left(\frac{22.50}{13.75}\right)^{\frac{7}{6}} \times 315 = 558 \text{ I.H.P.}$$

So that after the derived curve has been plotted from the spots calculated as above for various speeds, it must be continued in the same contour until it is opposite the 21-knot ordinate, when the required power may be read off.

STANDARD CURVES OF POWERS.

Taylor in his "Resistance of Ships" advocates the adoption of a "standard" displacement in applying the Law of Comparison, to which all trial particulars should be reduced, and for this purpose takes 10,000 tons as a basis, giving tables of factors to facilitate the reduction of the speed and power data possessed, to this standard displacement.

He makes each curve cover a range of one knot, after the manner shown on Fig. 54. As an example of the method employed in estimating the indicated horse power by the aid of these standard curves and tables, let us postulate that the power is required for a proposed ship of:

Length	440 feet.
Breadth	48 feet.
Draught	19.5 feet.
Displacement	7,000 tons.
Coefficient, δ	.595.
Speed	18½ knots.

Then to reduce 10,000 tons displacement, dimension, speed, and power factors are calculated.

In the above case these are 1.126, 1.061, and 1.517 respectively, which work out :

Length $\times$ 1.126 = 495.44 feet.
Breadth $\times$ 1 126 = 54.04 feet.
Draught $\times$ 1.126 = 21.96 feet.
Speed $\times$ 1.061 = 19.63 knots.

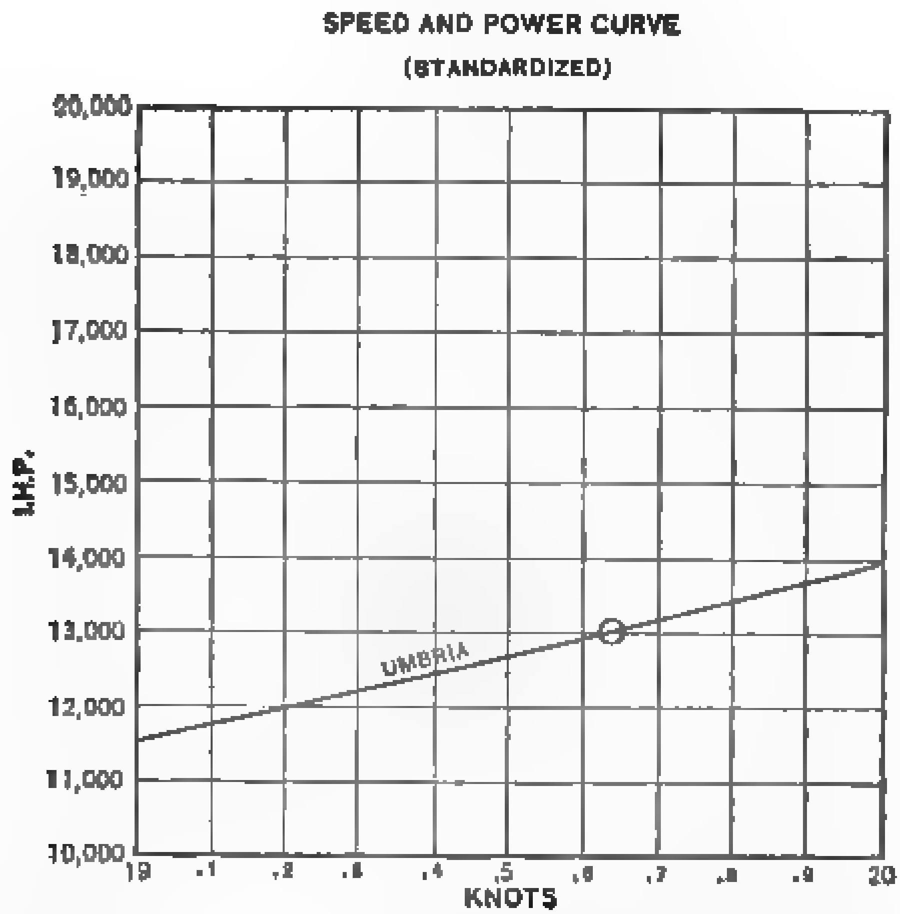


FIG. 54.

From the diagram shown we find that the "Umbria" at 19.63 knots took 13,000 I.H.P. at 10,000 tons standard displacement, and this divided by the power factor 1.517, will give the I.H.P. required, viz.:

$$\frac{13,000}{1.517} = 8,570 \text{ I.H.P.}$$

Any one may prepare a set of these standard curves, making each one cover a range of one knot, from his own trial data. These will be found very useful, as of the many methods

employed to estimate horse power, this is probably one of the most reliable, besides being easy of application. Of course, to do this one must be possessed of the requisite data and the judgment to know how to apply it.

In conjunction with the curves, tables should also be calculated for the dimension, speed, and power factors for graduated displacements as follows :

The dimension factor is the ratio of the linear dimensions, as:

Ratio of displacement, $\dfrac{10,000}{7,000} = 1.43$;

therefore, dimension factor

$$l = \sqrt[3]{1.43} = 1.126$$

for 7,000 tons displacement.

$$\text{Speed factor} = \left(\frac{10,000}{7,000}\right)^{\frac{1}{6}} = 1.061,$$

and
$$\text{Power factor} = \frac{10,000}{7,000} \times 1.061 = 1.517.$$

I.H.P. by Independent Method.

Where the type of vessel is abnormal, the speed excessive, or sufficient data to which to apply the comparative method is not possessed, the effective horse power should be calculated in detail from the skin and wave resistances, and by the selection of a suitable efficiency coefficient for the machinery, the Indicated Horse Power may be computed with great accuracy. For this purpose it is necessary to know the wetted surface, and this may be figured with the aid of either of the tables given on p. 98.

The wetted surface determined, this area must be multiplied by the coefficient of friction due to the particular surface which will give the skin friction, and this in turn multiplied by the power necessary to overcome one pound resistance at one knot (.0030707 V) by the 1.83 power of the velocity required, will give the E.H.P. for skin resistance. Otherwise stated,

$$\text{Skin resistance power} = f.S.\ .00307\,V^{2.83} = E_s.$$

To this must be added the power for residuary or wave-making resistance E_w.

$$\text{Wave resistance power} = .00307\,bV^5 = E_w.$$

Then these two combined give us the E.H.P. for the total resistance, from which the I.H.P. may be determined by taking a suitable coefficient of efficiency.

It should be stated that "b" ranges from .35 in swift, narrow vessels, to .55 in full, slow vessels.

Substituting values and applying them to the determination of the I.H.P. required for the 440-ft. steamer dealt with on p. 189, we have,

Wetted surface $= 26{,}600$ sq. ft. $= S$.
Coefficient of friction "f" $= .009$.
Power per pound of resistance at one knot $= .00307\ V$.
Percentage of efficiency $= 60\%$ of I.H.P.
Speed in knots $V = 18.5$.
Coefficient $b = .35$.

Then, $$E_s = .009 \times 26{,}600 \times .00307\ V^{2.83}$$
$$= 2{,}830 \text{ E.H.P.}$$

And, $$E_w = .00307 \times .35 V^5$$
$$= 2{,}330 \text{ E.H.P.}$$

The addition of the skin and wave resistance powers gives us the total effective horse power.

$$\text{E.H.P.} = 2{,}830 + 2{,}330 = 5{,}160$$

and the indicated horse power at 60% efficiency $= 8{,}600$ I.H.P., being a similar result to that obtained by the comparative method.

Froude's Frictional Constants for Salt Water or Smoothly Painted Surfaces.

Length of Vessel.	Coefficient of Friction.	Length of Vessel.	Coefficient of Friction.
50	.00963	200	.00902
60	.00950	250	.00897
70	.00940	300	.00892
80	.00933	350	.00889
90	.00928	400	.00886
100	.00923	450	.00883
120	.00916	500	.00880
140	.00911	550	.00877
160	.00907	600	.00874
180	.00904	. . .	. . . .

FORM OF LEAST RESISTANCE, BY MIDDENDORF'S METHOD.

Herr Middendorf gives the following method of obtaining the angles of entrance and run to give the form of least resistance, and

Table Giving Angles of Entrance and Run

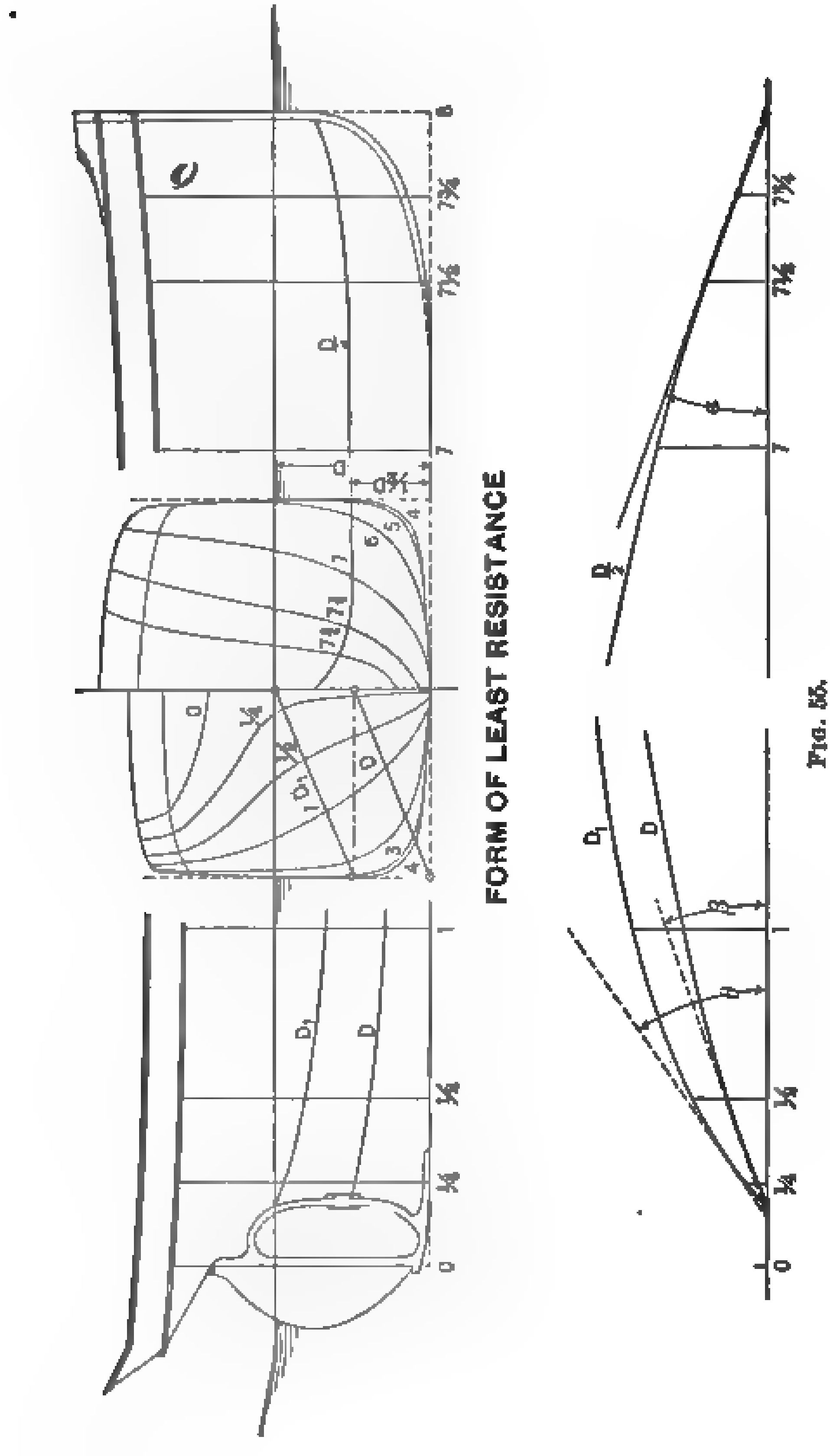
Lengths

Speed in Knots.	26 Ft. to 40 Ft.		40 Ft. to 65 Ft.		65 Ft. to 90 Ft.		90 Ft. to 125 Ft.		125 Ft. to 165 Ft.		165 Ft. to 200 Ft.	
	α and β	ϕ	α and β	ϕ	α and β	ϕ	α and β	ϕ	α and β	ϕ	α and β	ϕ
	°	°	°	°	°	°	°	°	°	°	°	°
5	18.0	30.5	18.5	31.5	20.0	33.0	21.0	35.0	22.5	37.0	24.0	39.5
6	17.0	29.0	17.5	30.0	18.5	31.5	20.0	33.0	21.5	35.0	23.0	37.5
7	16.0	27.5	16.5	28.5	17.5	29.5	18.5	31.0	20.0	33.0	21.5	35.0
8	15.0	25.5	15.5	26.5	16.5	27.5	17.5	29.0	19.0	31.0	20.0	33.0
9	14.5	24.0	14.5	25.0	15.5	26.0	16.5	27.5	17.5	29.0	18.5	30.5
10	13.5	22.5	14.0	23.0	14.5	24.0	15.5	25.5	16.5	27.0	17.5	28.5
11	12.5	21.0	13.0	21.5	13.5	22.0	14.5	23.5	15.0	25.0	16.0	26.5
12	11.5	19.5	12.0	20.0	12.5	20.5	13.0	21.5	14.0	23.0	15.0	24.5
13	10.5	18.0	11.0	18.5	11.5	19.0	12.0	20.0	13.0	21.0	13.5	22.5
14	10.0	16.5	10.5	17.0	10.5	17.5	11.0	18.5	12.0	19.5	12.5	21.0
15	9.0	15.5	9.5	16.0	10.0	16.5	10.5	17.0	11.0	18.0	11.5	19.0
16	8.5	14.5	8.5	14.5	9.0	15.0	9.5	16.0	10.0	16.5	10.5	17.5
17	8.0	13.5	8.0	13.5	8.5	14.0	9.0	14.5	9.0	15.5	9.5	16.5
18	7.5	12.5	7.5	12.5	7.5	13.0	8.0	13.5	8.5	14.5	9.0	15.0
19	7.0	11.5	7.0	12.0	7.0	12.5	7.5	13.0	8.0	13.5	8.5	14.0
20	6.5	11.0	6.5	11.0	7.0	11.5	7.0	12.0	7.5	12.5	8.0	13.0
21	...	...	6.0	10.5	6.5	11.0	6.5	10.5	7.0	11.5	7.5	12.0
22	...	...	...	...	6.0	10.5	6.0	10.5	6.5	11.0	7.0	11.5
23	...	...	...	...	...	...	6.0	10.0	6.0	10.5	6.5	10.5
24	...	...	...	...	...	...	...	...	6.0	10.0	6.0	10.0
25	...	...	...	...	...	...	...	...	...	...	6.0	9.5
26	...	...	...	...	...	...	...	...	...	...	...	...

for Ships of Various Lengths and Speeds.

in Feet.

200 Ft. to 260 Ft.		260 Ft. to 320 Ft.		320 Ft. to 390 Ft.		390 Ft. to 460 Ft.		460 Ft. to 540 Ft.		540 Ft. to 620 Ft.		620 Ft. to 720 Ft.	
α and β	θ	α and β	θ	α and β	θ	α and β	θ	α and β	θ	α and β	θ	α and β	θ
°	°	°	°	°	°	°	°	°	°	°	°	°	°
26.0	42.0	27.5	44.5	...	...	...	...	...	...	...	...	...	...
24.5	39.5	26.5	42.0	28.0	44.5	...	...	...	...	...	...	...	...
23.0	37.0	24.5	39.5	26.5	42.0	28.0	44.5	...	...	...	...	...	...
21.5	35.0	23.0	37.0	25.0	39.5	26.5	41.5	28.0	44.0	...	...	...	...
20.0	32.5	21.5	34.5	23.0	36.5	24.5	39.0	26.5	41.0	28.5	44.0	...	...
19.0	30.5	20.0	32.0	21.5	34.0	23.0	36.0	24.5	38.5	26.5	41.0	28.5	44.0
17.5	28.0	18.5	30.0	20.0	32.0	21.5	34.0	23.0	36.0	25.0	38.0	26.5	41.0
16.0	26.0	17.0	27.5	18.5	29.5	20.0	31.5	21.5	33.5	23.0	35.5	25.0	38.0
14.5	24.0	15.5	25.5	17.0	27.5	18.5	29.0	20.0	31.0	21.5	33.0	23.0	35.0
13.5	22.0	14.5	23.5	15.5	25.0	17.0	27.0	18.5	28.5	20.0	30.5	21.0	32.5
12.5	20.0	13.0	21.5	14.5	23.0	15.5	25.0	17.0	26.5	18.0	28.0	19.5	30.0
11.5	19.0	12.0	20.0	13.0	21.5	14.0	23.0	15.5	24.5	16.5	26.0	18.0	27.5
10.5	17.5	11.0	18.5	12.0	19.5	13.0	21.0	14.0	22.5	15.0	23.5	16.5	25.0
9.5	16.0	10.0	17.0	11.0	18.0	12.0	19.5	13.0	20.5	13.5	21.5	15.0	22.5
9.0	14.5	9.5	15.5	10.0	16.5	11.0	17.5	11.5	18.5	12.5	19.5	13.5	20.5
8.0	13.5	8.5	14.5	9.0	15.0	10.0	16.0	10.5	17.0	11.0	17.5	12.0	18.5
7.5	12.5	8.0	13.0	8.5	13.5	9.0	14.5	9.5	15.0	10.0	16.0	11.0	16.5
7.0	11.5	7.5	12.0	8.0	12.5	8.5	13.0	9.0	13.5	9.5	14.0	9.5	15.0
6.5	11.0	7.0	11.5	7.5	11.5	7.5	12.0	8.0	12.5	8.5	13.0	8.0	13.5
6.0	10.0	6.5	10.5	7.0	10.5	7.0	11.0	7.5	11.0	7.5	11.5	9.0	12.0
6.0	9.0	6.0	10.0	6.0	10.0	6.0	10.0	6.5	10.5	7.0	10.5	7.0	11.0
6.0	9.0	6.0	9.0	6.0	10.0	6.0	10.0	6.0	10.5	6.5	10.5	7.0	10.5



FORM OF LEAST RESISTANCE

Fig. 55.

appended is a table giving the value of these angles for various speeds and lengths of vessels obtained from actual well-known ships of the best form.

On the construction lines of the body plan and profile, a mean water line is drawn half way between keel and load line, as shown at $\frac{D}{2}$.

By referring to the table of angles, a is selected for the length of vessel being designed and the tangent of the same spotted on the half-breadth plan. This will give the outline of the mean water plane.

Two diagonals, D and D_1, are struck in on the after body plan, the former intersecting the centre line at half the draught, as well as the base line at a distance equal to the half-breadth of the ship, and D_1 intersecting the load water plane at centre line as well as the half moulded breadth construction line at the mean water line height, as shown in Fig. 55.

The angles β and θ are obtained from the table and transferred to the half-breadth plan representing the half planes of D and D_1 respectively.

ELEMENTS OF

Name.	Description.	Moulded Dimensions: Length. '	Breadth. '	Breadth. "	Depth. '	Depth. "	Draught. '	Draught. "	Displacement.	Block Coefficient, δ.	Prismatic Coefficient, p.	Mid-Area Coefficient, β.
Campania .	1st Class Ocean Liner, T.S. . .	600	65	0	41	6	26	10	19,336	.644	.667	.976
Manchuria	1st Class Intermediate Liner, T.S.	600	65	0	43	3	33	2	26,514	715	.762	.942
Normannia	1st Class Ocean Liner, T.S. . .	500	57	3	38	0	24	0	11,588	.59	.625	.94
Tantallon Castle .	1st Class Cape Liner	440	50	5	34	11	24	6	10,100	.647	.695	.932
Kiev . . .	Russian Volunteer Fleet	419	49	6	32	0	23	11½	10,640	.738	.769	.959
Texan . .	1st Class Ocean Freighter, T.S. .	471	57	0	35	0	27	0	16,236	784	.820	.958
Nevadan .	1st Class Ocean Freighter, T.S .	360	46	0	27	2	23	0	8,217	.758	788	.961
M. S. Dollar . . .	Ocean Freighter, S.S.	300	40	0	26	0	22	0	5,960	79	.801	.986
Victoria .	Channel, T.S. . .	220	28	0	17	0	10	0	860	502	.509	.822
Jupiter . .	Sound, P.S. . . .	230	28	0	9	6	6	7½	609	.578	.621	.930
Greyhound	Channel, P.S. . .	230	27	0	10	0	6	10½	690	.568	.622	.913
Tynwald* .	Channel, T.S. . .	265	34	4	14	6	10	0	1,508	.58	.594	.976
Sandy Hook	Sound, T.S. . . .	260	37	0	16	0	10	2	1,165	.417	.5	.82
Mayflower .	Yacht, T.S. . . .	275	36	6	21	0	15	4	2,414	.535	612	.874
Giralda . .	Yacht, T.S. . . .	275	35	0	19	0	13	6	1,862	.500	.498	.904
Ophelie* .	Yacht, Auxiliary Composite . .	160	26	6	17	0	11	6	568	.407	.59	.682
Lady Torfrida* . .	Yacht, Auxiliary Steel	157	27	0	17	0	11	6	552	.3968	.6	.664
Zaida* . .	Yacht, T S. . . .	136¾	22	6	13	9	8	9	332	.428	.59	.73
Pizzaro . .	Guard Boat, S.S. .	156	21	6	11	0	6	6½	303	482	.626	.773
Ponce de Leon . .	Guard Boat, S S.	135	19	0	10	6	6	6½	202	.439	.594	74
Sandoval .	Guard Boat, S.S. .	110	15	6	8	9	5	0	100	407	.610	.667
Fradera* .	Guard Boat, S S	74	11	9	7	3	4	0	41	.412	.662	.622
Seud* .	Speed Launch, S.S	86	10	7	5	10	2	9	30	.43	.625	.687
Neuquen* .	Revenue Steamer, S S . .	65	12	0	7	0	4	3	41½	.437	.585	757
Princess Maud* .	Customs Launch, S S	55	12	0	6	8	4	6	37	436	.56	776

* Designed by the Author.

TYPICAL STEAMERS.

Area L.W.L. Coefficient, d.	Net Steel, Tons.	Coefficient.	Wood and Outfit, Tons.	Coefficient.	Hull, Tons.	Coefficient.	Machinery (Steam Up), Tons	Displacement on Trial, Tons.	I.H.P.	Revolutions per Minute.	Speed, Knots.	Admiralty Constant.
.726	7,610	.4702	2,960	.1829	10,570	.6531	4,665	17,678	29,246	79	22.09	262
.826	7,967	.474	1,844	.1092	9,831	.583	2,100	. . .	12,000	75	14	. . .
.718	4,525	.416	1,677	.154	6,202	.57	2,525	10,535	16,300	94	20.75	263
.777	. . .	. . .	. . .	. . .	. . .	. .	. .	7,161	8,379	79	17.23	227
.837	2,827	.426	1,167	.1758	3,995	.6010	627	9,065	3,844	98	13.93	306
.875	3,891	.463	637	.0764	4,528	.539	731	8,390	3,535	75	12.8	245
.847	2,125	.472	531	.118	2,654	.59	528	. . .	3,000	75	. . .	. . .
.863	1,210	.388	328	.105	1,538	.493	447	2,522	1,302	88	11.25	207
.667	272	.26	172	.1641	444	424	203	736	1,400	201	16.5	260
.693	196	[illegible]	98	.1602	394	.48	221	550	2,425	50	18.18	116
.698	195	.314	88.5	1425	283.5	.4565	195.5	524	2,022	58	18.49	203
.67	446	.338	236	.179	682	.517	590	. . .	5,200	161	18.92	. . .
. . .	. . .	. .	. .	. . .	. . .	. . .	. . .	1,130	2,800	128	17.0	190
.721	994	.4716	672	.3180	1,666	.7902	[illegible]	2,365	4,604	167	16.38	169
.688	700	.3823	347	.1896	1,047	.5718	[illegible]	1,661	7,223	218	20.64	172
.692	115	.164	221	.3160	[illegible]	.4790	83	592	646	110	11.73	164
[illegible]	200	.2775	140	.1945	340	.4720	85	698	720	134	11.62	155
.683	132	.312	70	.1663	202	.4773	92	353	620	150	12.8	169
.694	91	.248	39	1073	[illegible]	.3555	55	257	504	242	13.4	193
.652	59	.2193	37	.136	96	.3554	58	167	338	270	13.14	203
.668	31	.2088	24	.1618	55	.3706	29	101	229	294	12 09	167
.67	14	.219	6	.125	22	.344	8¼	41	180	296	11.5	100
.688	9	.17	4.4	.083	13.4	.253	14.6	31¼	531	430	20.34	155
.696	12	.22	5	092	17	.312	12.5	39¼	97	318	10.1	119
[illegible]	16	.364	4.5	102	20.5	466	10.5	37	81	[illegible]	8.27	108

SECTION II.

STRENGTH OF MATERIALS.

CHAPTER I.

STRESSES.

IT is by the application of the known strengths, as derived by experiment, of the various materials used in shipbuilding to the physical properties possessed by their geometrical sections that we are enabled to calculate with accuracy the loads they will bear with a predetermined margin of safety when subjected to either of the four simple stresses of tension, compression, shearing and torsion.

Ultimate Strength is the direct stress producing rupture of the material.

Working Load is the stress applied in practice, and its ratio to the ultimate strength varies with the nature of the stresses applied, viz.: (1) tension with a dead load; (2) tension with a live load, or (3) a live load working alternately in opposite directions (see Table).

Many of the fittings in shipwork come under the third category, as in rudders, derricks, etc. In derricks the inertia of the load has not only to be overcome, but also the jarring and surging. For this reason a very common factor of safety for these details is ten times the ultimate strength.

Proof Strength is the test load to which cranes, davits, derricks, chains, cables, etc. are subjected, and is usually a multiple of the working load or ultimate strength. Careful measurements should be taken before applying this load, and these checked after the load has been removed, to discover, if any, the amount of permanent set.

Stress and Strain.— Stress is the measure of the internal force or resistance in a bar due to the load applied tending to produce

deformation, and strain is the alteration of form due to the stress. So that the relationship between these two terms really is one of cause and effect, although in general the terms are erroneously used synonymously.

Stress is measured by weight and strain in inches, or as a percentage of the length of the bar or member strained. Thus, we say that a 5-foot bar is subjected to a tensile *stress* of *20 tons*, producing a *strain* of *⅛ inch per foot* (elongation being ⅝ inch) or 1.04 per cent of the bar's length.

Tensile Stress.—If two equal forces acting in opposite directions, away from each other, be applied to a bar, they will tend to stretch it, thus producing a *tensile strain.*

Compressive Stress.—Should, however, the forces act towards one another they will produce a compressive strain.

Shearing Stress.—When two forces acting in opposite directions are exerted through the cross section of a pin or rivet connecting two flat bars, the pin is subjected to *single shear.* If, however, another similar bar be connected enclosing either of the other bars, then the pin or rivet will be in *double shear*, and may be reduced by half its original sectional area.

Bending or Transverse Stress.—Bending stresses are imposed on beams when they are loaded or forces exerted on them, although more correctly, tensile, compressive and shearing stresses are at work simultaneously on the top, bottom and abutments respectively.

Torsional Stress is encountered mostly in shafting and in the rudder stocks of ships. In the latter case it consists of twisting stresses acting alternately in opposite directions, requiring a much larger margin of safety than necessary with any of the other stresses named.

Resilience.—This term is applied to the amount of work done by compressing or extending a bar and multiplying the length of such compression or extension by the load which produced it.

Elasticity is the property which substances possess of returning to their original size and shape after straining. In tension materials increase in length and decrease under compressive stresses, and within certain limits this lengthening or shortening is proportional to the stress applied. From this it is evident that this quality is more important than even the *strength* of the material in tension or compression.

Modulus of Elasticity.—The amount of this proportional variation of the weight applied and the alteration in length of the

bar is known as the modulus of elasticity, and may also be expressed as the tensile force, which, when applied, will double the bar's length, and of course may be different in the same material when subjected to tension, compression or shear.

Permanent Set.—If a bar be extended or contracted by the application of a load beyond its elastic limit, it is said to have permanent set. This would take place in mild steel if a load of 17 tons per square inch of section were exceeded.

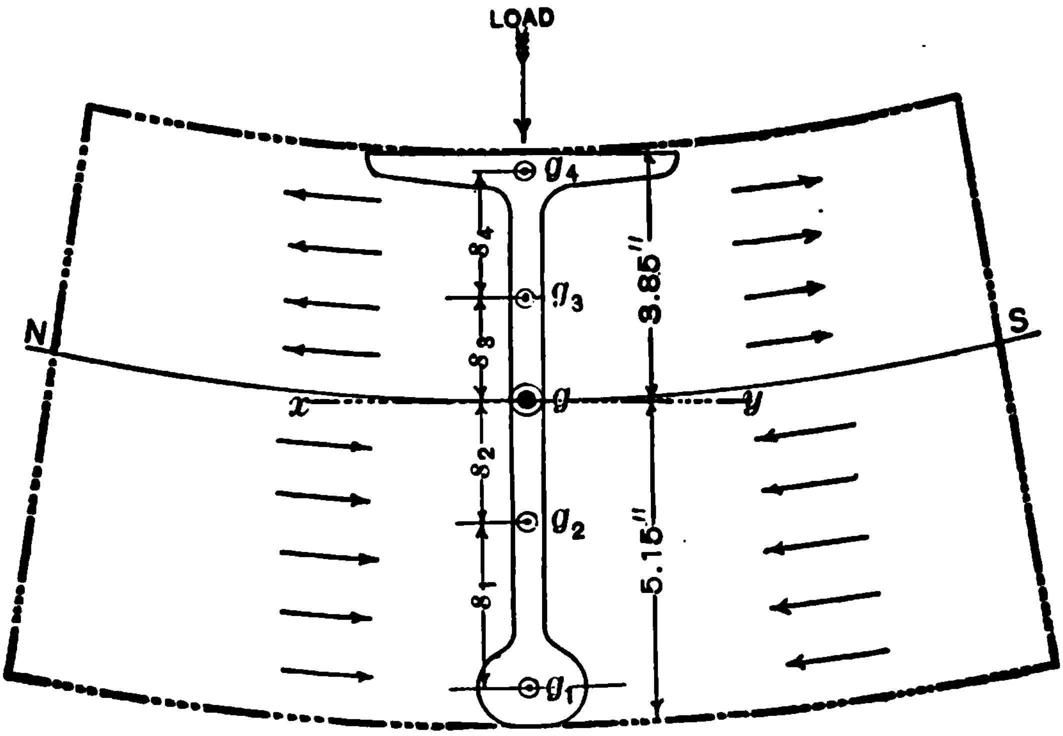


FIG. 56.

DISTANCES.				AREA.		MOMENTS.
S_1	=	4.40	×	2.04	=	39.49
S_2	=	1.75	×	1.48	=	4.73
S_3	=	2.00	×	1.64	=	6.56
S_4	=	3.75	×	2.44	=	34.30
Moment of Inertia I					=	85.08

Section Modulus $Z = \dfrac{85.08}{5.15} = 16.5.$

The Moment of Inertia of a section or body is a mathematical quantity used to calculate the strength of materials, and is taken relatively to the neutral axis or centre of gravity of the section. If the section of a bulb tee beam, as shown in Fig. 56, be centrally loaded on top, the fibres above the line xy (neutral axis) will be compressed, and those below extended, and consequently the arc formed by the table of the beam will be shorter, and that formed by the bulb longer, than the arc through the line NS,

which will be exactly the same length as the original dimension of the beam before the application of the load, the laminæ through this axis being neither in compression nor tension, and are therefore known as the *neutral surface* of the beam. Hence, if we take very small areas at known distances from the neutral axis to their centres of gravity and multiply these areas by the square of their distances above or below this line, we shall have by adding the products together the moments of inertia (I) of the section ; and again by dividing this moment by the distance of the most extreme fibre we shall get the quantity known as the **section modulus.**

In the example given the result is fairly accurate, although a more absolute result may be obtained by greater subdivision of the areas. This, however, is not necessary for ordinary calculations.

The value of the *section modulus* depends entirely on the geometrical form of the section. The material of which the beam is made and its ultimate strength known and divided by the factor of safety selected, gives us the safe limiting stress. This stress multiplied by the section modulus produces the **moment of resistance** of the beam. In the example given let the beam be of steel of 60,000 lbs. ultimate strength and the factor of safety 5, we then have $\frac{60000}{5} = 12{,}000$ lbs. safe limiting stress, and section modulus $= 16.5 \times 12{,}000$ lbs. $= 198{,}000$ lbs. moment of resistance. Suppose then that this were a 12-foot boat skid beam fixed at both ends and loaded at centre, what weight of steam pinnace would it safely support ? The maximum bending moment on a beam so loaded would be $\frac{1}{8}$ WL where W is the weight and L the length between points of support. Equating this bending moment with the moment of resistance, we have

$$\frac{SZ}{5} = \frac{WL}{8};$$

then $$W = 11{,}000 \text{ lbs.}$$

Where the figure or section is symmetrical about its centre of gravity the I and other elements may be readily figured from the appended Table of Elements of Usual Sections.

Radius of Gyration. — The radius of gyration is that fundamental property of a section used in determining the strength of pillars and struts, and its square or r^2 about a given axis is equal to the moment of inertia of the surface about the axis divided by the area, therefore the radius of gyration

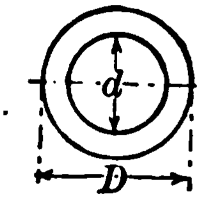
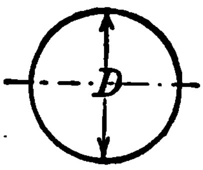
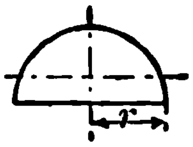
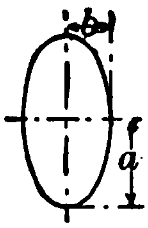
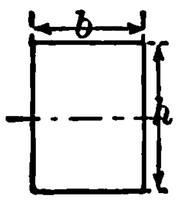
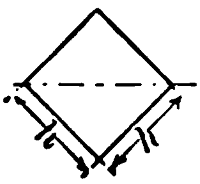
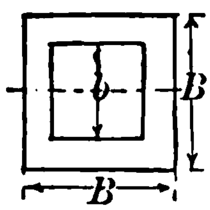
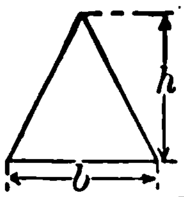
$$r = \sqrt{\frac{\text{inertia}}{\text{area}}}.$$

VARIOUS STRESSES AND THEIR FACTORS.

Strength and Intensity of Load.		Wrought Iron.	C = 0.25 — 0.05% Melting Point. 2,500° — 2,600° F.		C = 1.50 — .25% Melting Point 2,400° — 2,550° F.		Steel Castings.		Cast Iron.	Phosphor Bronze.	Gun-Metal.
Ultimate Tensile Strength.		47,000 to 57,000	48,000	63,000	64,000	140,000	50,000	100,000	17,000 to 26,000	56,000	42,000
			y — 12 — 25%		y = 10% - 0%		y = 8 — 10				
Tension	I	13,000	13,000	17,000	17,000	21,300	8,500	13,000	4,200	10,700	4,300
	II	8,500	8,500	11,400	11,400	14,200	5,700	8,500	2,800	7,100	2,800
	III	4,300	4,300	5,700	5,700	7,100	2,800	4,300	1,400	3,600	1,400
Compression	I	13,000	13,000	17,000	17,000	21,300	13,000	17,000	13,000	. . .	. . .
	II	8,500	8,500	11,400	11,400	14,200	8,500	13,000	8,500	. . .	. . .
Bending	I	13,000	13,000	17,000	17,000	21,300	10,700	15,000	. . .	10,700	4,300
	II	8,500	8,500	11,400	11,400	14,200	7,100	10,000	. . .	7,100	2,800
	III	4,300	4,300	5,700	5,700	7,100	3,500	5,000	. . .	3,600	1,400
Shearing	I	10,000	10,200	13,700	13,700	17,000	6,800	12,000	4,200	. . .	. . .
	II	6,800	6,800	9,100	9,100	11,400	4,600	8,000	2,800	. . .	. . .
	III	3,400	3,400	4,600	4,600	5,700	2,300	4,000	1,400	. . .	. . .
Twisting	I	5,100	8,500	12,000	13,000	17,000	6,800	12,000	. . .	4,300	. . .
	II	3,400	5,700	8,000	8,500	11,400	4,600	8,000	. . .	2,800	. . .
	III	1,700	2,800	4,000	4,300	5,700	2,300	4,000	. . .	1,400	. . .

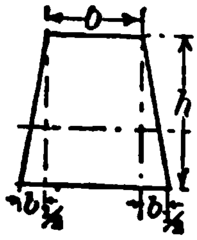
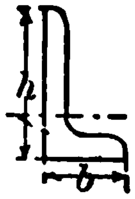
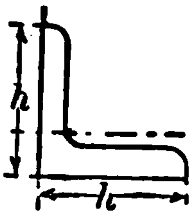
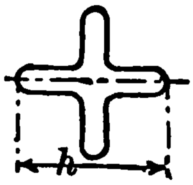
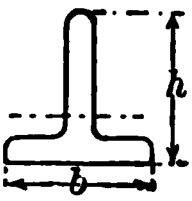
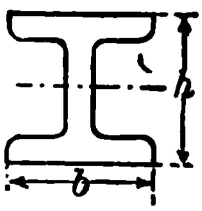
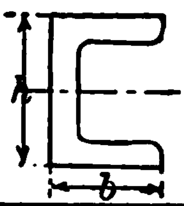
y = elongation %. I = dead load, II = live load, III = live load, acting alternately in opposite directions.

ELEMENTS OF SECTIONS.

Section.	Moment of Inertia.	Section Modulus.	Base from C.G.	Least Radius of Gyration.
	$0.0491\,(D^4-d^4)$	$0.0982\,\frac{D^4-d^4}{D}$	$\frac{D}{2}$	$\frac{1}{4}\sqrt{(D^2+d^2)}$
	$\frac{AD^2}{16}$	$\frac{AD}{8}$	$\frac{D}{2}$	$\frac{D}{4}$
	$0.1098\,r^4$	$W_1 = 0.1098\,r^3$ $W_2 = 0.2587\,r^3$	$0.4244\,r$	$0.0699\,r^2$
	$0.7854\,ba^3$	$0.7854\,ba^2$	. . . .	. . . .
	$\frac{bh^3}{12}$	$\frac{bh^2}{6}$	$\frac{h}{2}$	$\frac{\text{Least side}}{3.46}$
	$\frac{h^4}{12}$	$0.1178\,h^3$	. . . .	$\frac{h}{3.46}$
	$\frac{B^4-b^4}{12}$	$\frac{1}{6}\,\frac{B^4-b^4}{B}$	$\frac{B}{2}$	$\sqrt{\frac{B^2+b^2}{12}}$
	$\frac{bh^3}{36}$	$\frac{bh^2}{24}$	$\frac{1}{3}h$	The lesser, $\frac{h}{4.24}$ or $\frac{b}{4.9}$

Figs. 57 to 64.

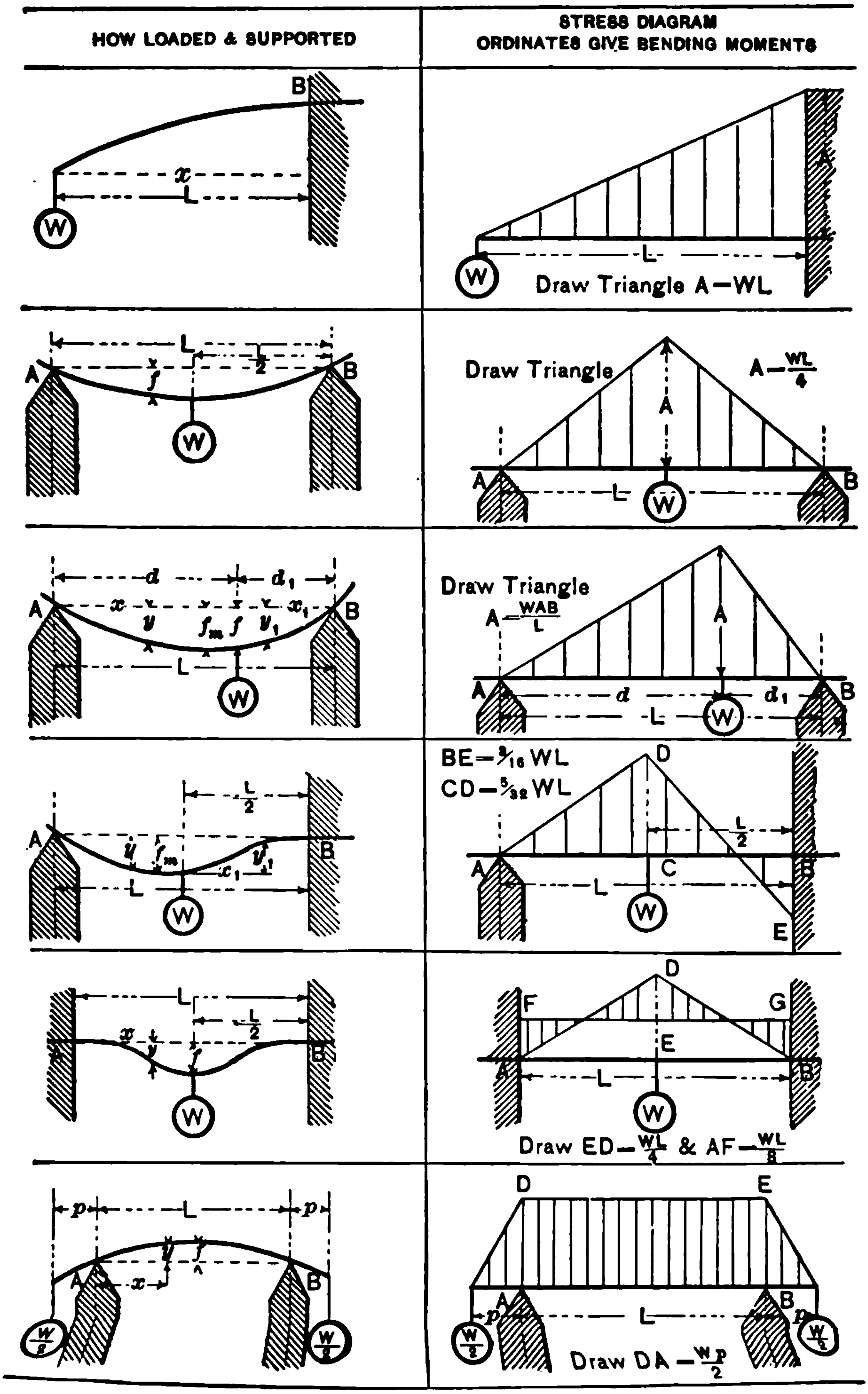
ELEMENTS OF SECTIONS. — (*Continued.*)

SECTION.	MOMENT OF INERTIA.	SECTION MODULUS.	BASE FROM C.G.	LEAST RADIUS OF GYRATION.
	$\frac{6b^2+6bb_1+b_1^2}{36(2b+b_1)}h^3$	$\frac{6b^2+6bb_1+b_1^2}{12(3b+2b_1)}h^2$	$\frac{1}{3}\frac{3b+b_1}{2b+b_1}h$	. . . .
	$\frac{Ah^2}{9.9}$	$\frac{Ah}{6.7}$	$\frac{h}{3.1}$	$\frac{hb}{2.6(h+b)}$
	$\frac{Ah^2}{10.4}$	$\frac{Ah}{7.4}$	$\frac{h}{3.5}$	$\frac{h}{5}$
	$\frac{Ah^2}{19}$	$\frac{Ah}{9.5}$	$\frac{h}{2}$	$\frac{h}{4.74}$
	$\frac{Ah^2}{10.9}$	$\frac{Ah}{7.6}$	$\frac{h}{3.3}$	$\frac{b}{4.66}$
	$\frac{Ah^2}{6.1}$	$\frac{Ah}{3.0}$	$\frac{h}{2}$	$\frac{b}{5.2}$
	$\frac{Ah^2}{6.73}$	$\frac{Ah}{3.3}$	$\frac{h}{2}$	$\frac{b}{3.56}$

FIGS. 65 TO 71.

BEAM BENDING MOMENTS, ETC.

W—LOAD. L—LENGTH OF BEAM BETWEEN SUPPORTS. K—FIBRE STRESS.
I—MOMENT OF INERTIA. E—MODULUS OF ELASTICITY. R—$\frac{I}{C}$—SECTION MODULUS.
C—DISTANCE OF EXTREME FIBRES FROM NEUTRAL AXIS.



FIGS. 72 TO 83.

BEAM BENDING MOMENTS, ETC.

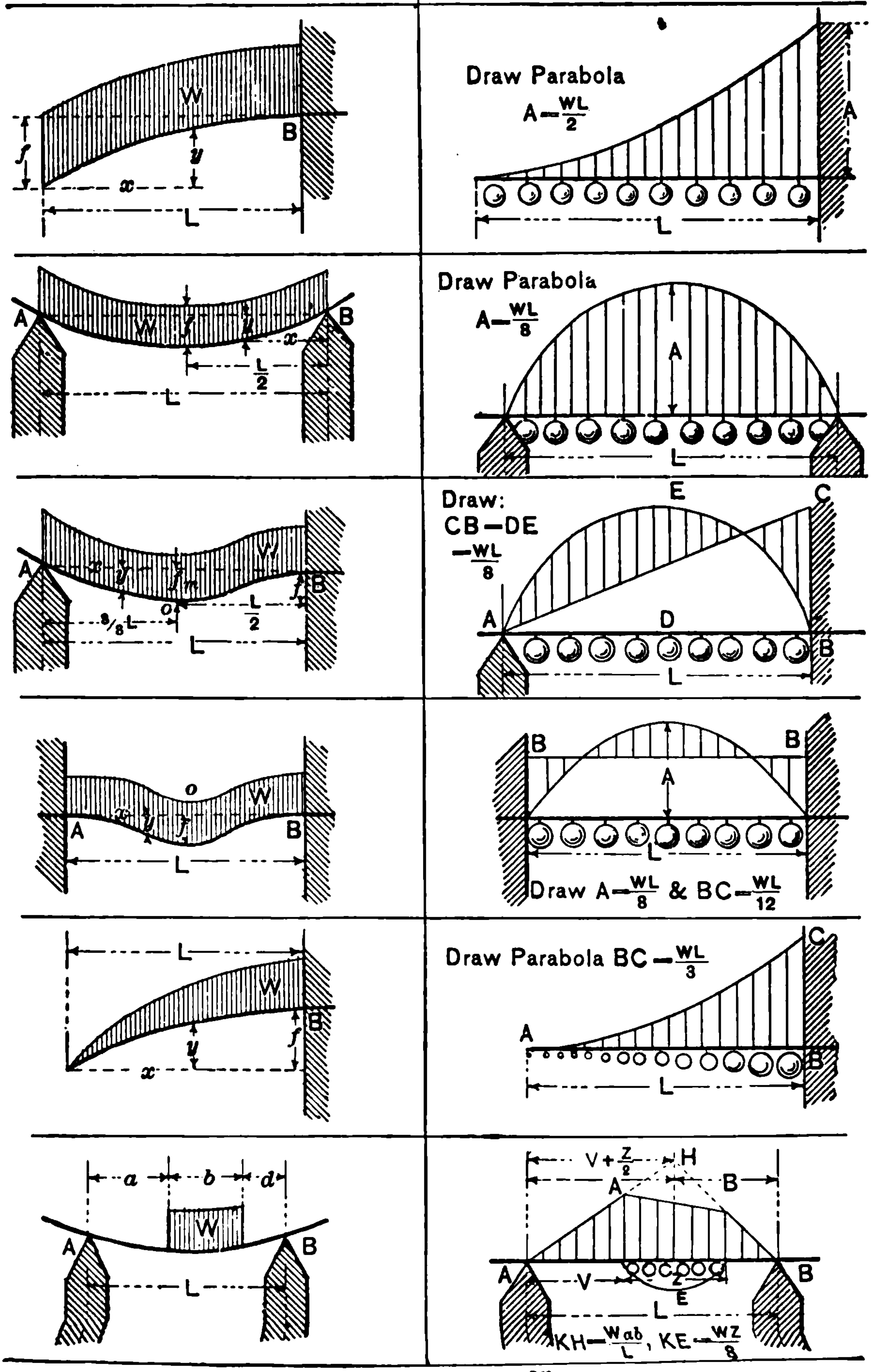
W = Load. L = Length of Beam between Supports.
K = Fibre Stress. I = Moment of Inertia.
E = Modulus of Elasticity. $R = \frac{I}{c}$ = Section Modulus.
C = Distance of Extreme Fibres from Neutral Axis.

Bending Moment, M.	Deflection, f.	Reaction at A and B. Safe Load W	Elastic Curve Equation.
$M = Wx$ $M_{max} = WL$	$f = \frac{W}{3}\frac{L^3}{EI}$	$B = W$ $W = \frac{KR}{L}$	$y = \frac{WL^3}{2EI}\left[\frac{x}{L} - \frac{1}{3}\frac{x^3}{L^3}\right]$
$M = \frac{Wx}{2}$ $M_{max} = \frac{WL}{4}$	$f = \frac{W}{48}\frac{L^3}{EI}$	$A = B = \frac{W}{2}$ $W = 4\frac{KR}{L}$	$y = \frac{WL^3}{16\,EI}\left[\frac{x}{L} - \frac{4}{3}\frac{x^3}{L^3}\right]$
For AD, $M = \frac{Wd_1x}{L}$ For BD, $M = \frac{Wdx_1}{L}$ $M_{max} = \frac{Wdd_1}{L}$	$f = \frac{1}{27}Wdd_1\frac{d_1+L}{EIL}\sqrt{3\,d\,(d_1+L)}$	$A = \frac{Wd_1}{L}$ $B = \frac{Wd}{L}$ $W = KR\frac{L}{dd_1}$	$y = \frac{Wd^2d_1^2}{6\,LEI}\left[2\frac{x_1}{d} + \frac{x_1}{d_1} - \frac{x^3}{d^2d_1}\right]$ $y_1 = \frac{Wd^2d_1^2}{6\,LEI}\left[\frac{2\,x_1}{d_1} + \frac{x_1}{d} - \frac{x_1^3}{d_1^2d}\right]$
For AD, $M = \frac{5}{16}Wx$ For BD, $M = WL\left(\frac{5}{32} - \frac{11}{16}\frac{x_1}{L}\right)$ $M_{max} = \frac{3}{16}WL$ $M_d = \frac{5}{32}WL$	$f = \frac{7\,WL^3}{768\,EI}$ $f_{max} = \sqrt{\frac{1}{5}} \times \frac{PL^3}{48\,EI}$ For $x = L\sqrt{\frac{1}{5}}$	$A = \frac{5}{16}W$ $B = \frac{11}{16}W$ $W = \frac{16}{3}\frac{KR}{L}$	$y = \frac{W}{32}\frac{L^3}{EI}\left[\frac{x}{L} - \frac{5}{3}\frac{x^3}{L^3}\right]$ $y_1 = \frac{W}{32}\frac{L^3}{EI} \times \left[\frac{1}{4}\frac{x_1}{L} + \frac{5}{2}\frac{x_1^2}{L^2} - \frac{11}{3}\frac{x_1^3}{L^3}\right]$
$M = \frac{WL}{2}\left(\frac{x}{L} - \frac{1}{4}\right)$ $M_{max} = \frac{WL}{8}$	$f = \frac{W}{192}\frac{L^3}{EI}$	$A = B = \frac{W}{2}$ $W = 8\frac{KR}{L}$	$y = \frac{W}{16}\frac{L^3}{EI} \times \left[\frac{x^2}{L^2} - \frac{4}{3}\frac{x^3}{L^3}\right]$
For A and B, $M = \frac{Wp}{2}$	$f = \frac{WL^2}{16}\frac{p}{EI}$	$A = B = \frac{W}{2}$ $W = 2\frac{KR}{p}$	$y = f - \rho + \sqrt{\rho^2 - x^2 + L\left(x - \frac{L}{4}\right)}$ $\rho = \frac{2EI}{Wd}$ = Constant

BEAM BENDING MOMENTS, ETC.

W—LOAD. L—LENGTH OF BEAM BETWEEN SUPPORTS. K—FIBRE STRESS.
I MOMENT OF INERTIA. E—MODULUS OF ELASTICITY. R—$\frac{I}{C}$—SECTION MODULUS.
C—DISTANCE OF EXTREME FIBRES FROM NEUTRAL AXIS.

HOW LOADED & SUPPORTED	STRESS DIAGRAM ORDINATES GIVE BENDING MOMENTS



FIGS. 84 TO 95.

BEAM BENDING MOMENTS, ETC. — (*Continued.*)

$W =$ Load. $L =$ Length of Beam between Supports.
$E =$ Modulus of Elasticity. $R = \frac{I}{c} =$ Section Modulus.
$K =$ Fibre Stress. $I =$ Moment of Inertia.
$C =$ Distance of Extreme Fibres from Neutral Axis.

Bending Moment, M.	Deflection, f.	Reaction at A and B. Safe Load, W.	Elastic Curve Equation.
$M = \frac{Wx^2}{2L}$ $M_{max} = \frac{WL}{2}$	$f = \frac{W}{8}\frac{L^3}{EI}$	$W = 2\frac{KR}{L}$ $B = W$	$y = \frac{W}{24}\frac{L^3}{EI}\left[4\frac{x}{L} - \frac{x^4}{L^4}\right]$
$M = \frac{Wx}{2}\left(1 - \frac{x}{L}\right)$ $M_{max} = \frac{WL}{8}$	$f = \frac{5}{384}\frac{WL^3}{EI}$	$A = B = \frac{W}{2}$ $W = 8\frac{KR}{L}$	$y = \frac{W}{24}\frac{L^3}{EI} \times \left[\frac{x}{L} - 2\frac{x^3}{L^3} + \frac{x^4}{L^4}\right]$
$M = \frac{Wx}{2}\left(\frac{3}{4} - \frac{x}{L}\right)$ $M_{max} = \frac{WL}{8}$ $M_0 = \frac{9}{128}WL$	$f = \frac{WL^3}{192\,EI}$ Max. deflection, $x = 0.4215\,L$	$A = \frac{3}{8}W$ $B = \frac{5}{8}W$ $W = 8\frac{KR}{L}$	$y = \frac{W}{48}\frac{L^3}{EI} \times \left[\frac{x}{L} - 3\frac{x^3}{L^3} + 2\frac{x^4}{L^4}\right]$
$M = \frac{WL}{2}\left(\frac{1}{6} - \frac{x}{L} + \frac{x^2}{L^2}\right)$ $M_{max} = \frac{WL}{12}$ $M_0 = \frac{WL}{24}$	$f = \frac{WL^3}{384\,EI}$	$A = B = \frac{W}{2}$ $W = 12\frac{KR}{L}$	$y = \frac{WL^3}{24\,EI}\left[\frac{x^2}{L^2} - \frac{2x^3}{L^3} + \frac{x^4}{L^4}\right]$
$M = \frac{W}{3}\frac{x^3}{L^2}$ $M_{max} = \frac{WL}{3}$	$f = \frac{WL^3}{15\,EI}$	$B = W$ $W = 3\frac{KR}{L}$	$y = \frac{WL^3}{12\,EI}\left[\frac{x}{L} - \frac{1}{5}\frac{x^5}{L^5}\right]$
$RK = A\left(a + \frac{bA}{2W}\right)$		$A = \frac{W(2d + b)}{2L}$ $B = \frac{W(2a + b)}{2L}$	

USE OF THE TABLE OF ELEMENTS OF CIRCULAR SECTIONS.

In calculating the scantlings of masts, derricks, kingposts, rudders, shafting, and details generally, where circular sections are employed, the Table of Elements will be found very convenient and time-saving, as, having determined on a thickness or a diameter to which it is decided to work, the appropriate formulæ for the various elements may be read off with facility.

In the first column is given the ratio of internal to external diameter. It is required to find the elements of a hollow section with an outside diameter $D = 5$ inches and an internal diameter $d = .8\ D = 4$ inches, or $5'' \times \frac{1}{2}''$ thick.

Column 2 gives the sectional area coefficient of the pipe, viz., $.2826 \times D^2 = 7.065$ square inches.

Similarly the coefficient for the moment of inertia, I, is found in the third column to be .02899 by the fourth power of the diameter D, or $.02899 \times 625 = 18.118 = I$.

By the fourth column we get the coefficient for the square of the least radius of gyration as $.1026\ D^2 = .1026 \times 25 = 2.565$, and in the following or fifth column the radius of gyration $= .32\ D = .32 \times 5'' = 1.6$.

For the modulus of resistance of the section, or I/y, the coefficient for the pipe with a ratio of $.8\ D$ is

$$.05798\ D^3 = .05798 \times 125 = 7.247.$$

The torsional modulus of resistance is

$$.11595\ D^3 = .11595 \times 125 = 14.493.$$

If it be required to select a diameter of hollow or solid circular section for a given moment of inertia, or, having obtained a diameter, it is found advisable to amend the same to another diameter giving the same I, then the increase or decrease of thickness may be readily computed with the aid of column 8, and in a like manner the sectional area for a constant moment of inertia is calculated by the coefficients in the following column.

The last two columns give, similarly, the diameters and areas for a constant moment of resistance.

Inversely we may calculate the diameter of a bar or tube equal to a given moment of inertia, or moment of resistance, or radius of gyration, etc. For example, the diameter is required of a tubular section which shall equal a moment of inertia of 12. It is proposed to make the pipe relatively thin; therefore we select a ratio of $d/D = .90$ per column one, from which we get an I coefficient $= .01689$; therefore,

$$D = \sqrt[4]{\frac{I}{.01689}} = \sqrt[4]{\frac{12}{.01689}} = \sqrt[4]{710}$$

$= 5.14$ *inches* outside diameter $\times \frac{1}{4}$ inch thick (fully).

MODULI OF CIRCULAR SECTIONS.

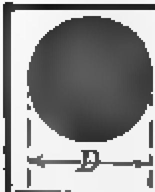
$$\frac{\pi D^3}{32} = .0982\, D^3$$

Dia.	0	1	2	3	4	5	6	7	8	9	10	11
0	0	.0982	.78560	2.6507	6.2848	12.2750	21.2112	33.682	50.279	71.918	98.20	130.70
$\frac{1}{32}$	.0000029	.10768	.82294	2.7350	6.4330	12.5066	......	......	......	......	......	......
$\frac{1}{16}$	.0000239	.11779	.86157	2.8205	6.5840	12.7411	21.8809	34.593	51.464	......	......	......
$\frac{3}{32}$	.0000809	.12554	.90127	2.9077	6.7360	12.9775	......	......	......	......	......	......
$\frac{1}{8}$	.0001918	.13981	.94229	2.9968	6.8910	13.2188	22.5647	35.519	52.672	74.612	101.92	135.21
$\frac{5}{32}$	.000374	.15178	.98441	3.0875	7.0502	13.4621	......	......	......	......	......	......
$\frac{3}{16}$	.000647	.16069	1.0279	3.1803	7.2106	13.7083	23.2625	36.462	53.897	......	......	......
$\frac{7}{32}$	.001028	.17775	1.0725	3.2745	7.3730	13.9576	......	......	......	......	......	......
$\frac{1}{4}$	.001534	.19179	1.1185	3.3710	7.5384	14.2098	23.974	37.422	55.141	77.720	105.50	139.82
$\frac{9}{32}$	.002184	.20652	1.1657	3.4690	7.7056	14.4651	......	......	......	......	......	......
$\frac{5}{16}$	.002996	.22202	1.2143	3.5692	7.8758	14.7234	24.701	38.398	56.403	......	......	......
$\frac{11}{32}$	.003988	.23824	1.2642	3.6711	8.0481	14.9847	......	......	......	......	......	......
$\frac{3}{8}$	.005178	.25528	1.3165	3.7751	8.2233	15.2492	25.442	39.391	57.685	80.914	109.65	144.53
$\frac{13}{32}$	.006584	.27305	1.3680	3.8808	8.4198	15.5167	......	......	......	......	......	......
$\frac{7}{16}$	.008223	.29477	1.4221	3.9887	8.5808	15.7873	26.197	40.401	58.987	......	......	......
$\frac{15}{32}$	.0101140	.31110	1.4774	4.0984	8.7630	16.0610	......	......	......	......	......	......
$\frac{1}{2}$	.01227	.33142	1.5343	4.2103	8.9485	16.3380	26.968	41.428	60.307	84.194	113.67	149.35
$\frac{17}{32}$	.014734	.35259	1.5955	4.3200	9.1359	16.6181	......	......	......	......	......	......
$\frac{9}{16}$	.017477	.37460	1.6523	4.3399	9.2837	16.9017	27.753	42.472	61.647	......	......	......
$\frac{19}{32}$	.020555	.39742	1.7134	4.5576	9.5191	17.1878	......	......	......	......	......	......
$\frac{5}{8}$	.023975	.42137	1.7762	4.6777	9.7151	17.4774	28.554	43.552	63.021	87.561	117.78	154.28
$\frac{21}{32}$	.027766	.44611	1.8403	4.7996	9.9130	17.7295	......	......	......	......	......	......
$\frac{11}{16}$	.031920	.47189	1.9061	4.9239	10.114	18.0665	29.370	44.613	64.386	......	......	......
$\frac{23}{32}$	.036462	.49856	1.9733	5.0499	10.313	18.3660	......	......	......	......	......	......
$\frac{3}{4}$	.041428	.52629	2.0422	5.1785	10.524	18.6683	30.201	45.710	65.786	91.017	121.99	159.30
$\frac{25}{32}$	.046826	.55494	2.1125	5.3088	10.733	18 9757	......	......	......	......	......	......
$\frac{13}{16}$	.052672	.58471	2.2355	5.4418	10.945	19.2841	30 976	46.815	67.206	......	......	......
$\frac{27}{32}$	.058986	.61544	2.2582	5.5765	11.159	19.5968	......	......	......	......	......	......
$\frac{7}{8}$	.065786	.64731	2.3346	5.7138	11.3771	19.9129	31.910	47.958	68 646	94.563	126.29	164.44
$\frac{29}{32}$	.073089	.68017	2.4104	5 8529	11.5973	20 2323	......	......	......	......	......	......
$\frac{15}{16}$	.080914	.71422	2.4891	5.9948	11.8206	20.5552	32 788	49 109	70 106	......	......	......
$\frac{31}{32}$	.089278	.74929	2.5693	6 1384	12 0462	20 8815	......	......	......	......	......	......

ELEMENTS OF CIRCULAR SECTIONS.
Solid and Hollow.

Outside Diameter D.	Sectional Area D^2	Moment of Inertia I.	Sq. of Least Radius of Gyration r^2.	Least Radius of Gyration r.	Modulus of Resistance $\frac{I}{y}$.	Torsion Resistance Mt.	Diameter D for Constant I.	Area A for Constant I.	Diameter D for Constant $\frac{I}{y}$.	Area A for Constant $\frac{I}{y}$.
$\frac{d}{D}=$	$.7854D^2$	$\frac{\pi}{64}D^4$	$\frac{D^2}{16}$	$\frac{D}{4}$	$\frac{\pi}{32}D^3$	$\frac{\pi}{16}D^3$				
1.00	$.785D^2$	$.04909D^4$	$.06257D^2$	$.25D$	$.09818D^3$	$.196D^3$	1.00	.785	1.000	.785
.25	$.736D^2$	$.04891D^4$	$.06645D^2$	$.258D$	$.09782D^3$	$.1956D^3$	1.00	.785	1.005	.745
.50	$.588D^2$	$.046D^4$	$.0781D^2$	$.2795D$	$.092D^3$	$.1840D^3$	1.016	.607	1.022	.654
.60	$.5024D^2$	$.04274D^4$	$.0850D^2$	$.2915D$	$.08348D^3$	$.16696D^3$	1.035	.5385	1.055	.561
.70	$.4004D^2$	$.037311D^4$	$.0932D^2$	$.3053D$	$.074622D^3$	$.149244D^3$	1.059	.449	1.096	.524
.80	$.2826D^2$	$.028989D^4$	$.1026D^2$	$.3200D$	$.057978D^3$	$.11595D^3$	1.141	.367	1.206	.494
.85	$.2179D^2$	$.02347D^4$	$.1078D^2$	$.328D$	$.04694D^3$	$.0937D^3$	1.203	.316	1.279	.356
.90	$.1492D^2$	$.01689D^4$	$.1125D^2$	$.3355D$	$.03378D^3$	$.06756D^3$	1.306	.2545	1.376	.2855
.92	$.1206D^2$	$.013925D^4$	$.1155D^2$	$.340D$	$.02785D^3$	$.0557D^3$	1.370	.2265	1.520	.2770
.94	$.09137D^2$	$.010763D^4$	$.11775D^2$	$.343D$	$.021526D^3$	$.04305D^3$	1.462	.195	1.680	.2580
.96	$.06154D^2$	$.007395D^4$	$.1204D^2$	$.347D$	$.01479D^3$	$.02958D^3$	1.605	.1585	1.880	.2172
.98	$.031086D^2$	$.00381D^4$	$.1225D^2$	$.350D$	$.00762D^3$	$.01524D^3$	1.895	.1116	2.343	.1710
1	2	3	4	5	6	7	8	9	10	11

MODULI OF CIRCULAR SECTIONS



INERTIA OF CIRCULAR SECTIONS.

I = Mom. of Inertia. Z = Section Modulus.

D	$I=\frac{\pi d^4}{64}$	$Z=\frac{\pi d^3}{32}$	D	$I=\frac{\pi d^4}{64}$	$Z=\frac{\pi d^3}{32}$	D	$I=\frac{\pi d^4}{64}$	$Z=\frac{\pi d^3}{32}$
1	0.0491	0.0982	34	65,597	3,859	67	989,166	29,527
2	0.7854	0.7854	35	73,662	4,209	[illegible]	1,049,556	30,869
3	3.976	2.651	36	82,448	4,580	69	1,112,660	32,251
4	12.57	6.283	37	91,998	4,973	70	1,178,588	33,674
5	30.68	12.27	38	102,354	5,387	71	1,247,393	35,138
6	63.62	21.21	39	113,561	5,824	72	1,319,167	36,644
7	117.9	33.67	40	125,664	6,283	73	1,393,995	38,192
8	201.1	50.27	41	138,709	6,766	74	1,471,963	39,783
9	322.1	71.57	42	152,745	7,274	75	1,553,156	41,417
10	490.9	98.17	43	167,820	7,806	76	1,637,662	43,096
11	718.7	130.7	44	183,984	8,363	77	1,725,571	44,820
12	1,018	169.6	45	201,289	8,946	78	1,816,972	46,589
13	1,402	215.7	46	219,787	9,556	79	1,911,967	48,404
14	1,886	269.4	47	239,531	10,193	80	2,010,619	50,265
15	2,485	331.3	48	260,576	10,857	81	2,113,051	52,174
16	3,217	402.1	49	282,979	11,550	82	2,219,347	54,130
17	4,100	482.3	50	306,796	12,272	83	2,329,605	56,135
18	5,153	572.6	51	332,086	13,023	84	2,443,920	58,189
19	6,397	673.4	52	358,908	13,804	85	2,562,392	60,292
20	7,854	785.4	53	387,323	14,616	86	2,685,120	62,445
21	9,547	909.2	54	417,393	15,459	87	2,812,205	64,648
22	11,499	1,045	55	449,180	16,334	88	2,943,748	66,903
23	13,737	1,194	56	482,750	17,241	89	3,079,853	69,210
24	16,286	1,357	57	518,166	18,181	90	3,220,623	71,569
25	19,175	1,534	58	555,497	19,155	91	3,366,165	73,982
26	22,432	1,726	59	594,810	20,163	92	3,516,586	76,448
27	26,087	1,932	60	636,172	21,206	93	3,671,992	78,968
28	30,172	2,155	61	679,651	22,284	94	3,832,492	81,542
29	34,719	2,394	62	725,332	23,398	95	3,998,198	84,173
30	39,761	2,651	63	773,272	24,548	96	4,169,220	86,859
31	45,333	2,925	64	823,550	25,736	97	4,345,671	89,601
32	51,472	3,217	65	876,240	26,961	98	4,527,664	92,401
33	58,214	3,528	66	931,420	28,225	99	4,715,315	95,259
. .	. . . . .	. . . . .	.	. . .	. .	100	4,908,738	98,175

$\pi : 64 = 0.0490874$; $\log (\pi : 64) = 0.6909699 - 2$.
$\pi : 32 = 0.0981748$; $\log (\pi : 32) = 0.9919999 - 2$.

CHAPTER II.

STRENGTH OF COLUMNS.

JOHNSON'S FORMULA.

The accompanying table of strengths of wrought iron columns is based on the "straight line" formula proposed by Johnson and generally used in America. The value of the constant K is deduced by making the straight line tangent to the curve of Euler's formula.

$$P = S - k\frac{L}{r}.$$

Where, $P =$ Ultimate compressive unit stress.
$S =$ Maximum tensile unit stress.
$k =$ A constant whose value depends on the condition of the ends, viz., fixed, flat, hinged or round.
$L =$ Length of column in feet.
$r =$ Least radius of gyration.

This formula may be readily memorized for wrought iron columns, thus: —

Ultimate unit stress $P = 52{,}500 - 2700\frac{L}{r}$, on which basis the table has been calculated.

EXAMPLE. — It is required to find the safe load with a factor of safety of 5 for a hollow wrought-steel strut or column with a length of 46 feet, mean diameter 20 inches and one-half inch thick.

$$r = 20 \times .35 = 7.$$
$$\frac{L}{r} = \frac{46}{7} = 6.57.$$

P (from table) $= 6{,}900$ lbs.
Area of column $=$ circ. $\times\, t = 62.8 \times .5 = 31.4\ \square''$
Safe Load $W = 6{,}900$ lbs. $\times\ 31.40\ \square'' \doteq 216{,}660$ lbs.
Or, if it be required to find the thickness t of the column in the foregoing example, the load being 216,660 lbs.

$$r = 7.$$
$$\frac{L}{r} = 6.57.$$
$$P = 6{,}900 \text{ lbs. (from table)}.$$

$$\text{Area} = \frac{216,660}{6,900} = 31.4 \ \square''.$$

$$t = \frac{\text{Area}}{\text{Circ.}} = \frac{31.4}{62.8} = .5 \text{ inch.}$$

Values of r for various sections.

When

$t = \frac{D}{10}$, $r = .32\ D.$

$t = \frac{D}{8}$, $r = .313\ D.$

$t = \frac{D}{6}$, $r = .301\ D.$

$t = \frac{D}{4}$, $r = .279\ D.$

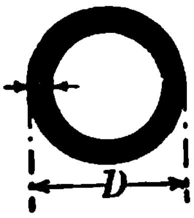


FIG. 96.

(See Table of Elements of Circular Sections.)

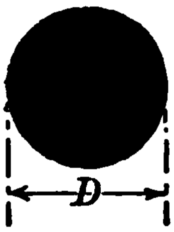


FIG. 97.

Least radius of gyration $= \frac{D}{4}$.

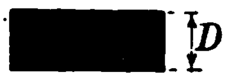


FIG. 98.

Rectangle or square $r = .289\ D.$

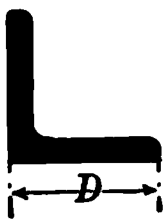


FIG. 99.

Equal sided angle bar $r = \frac{D}{5}$.

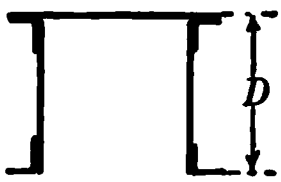


FIG. 100.

$r = .4\ D.$

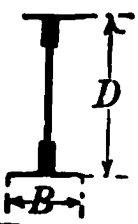


FIG. 101.

$r = \frac{3}{8}\ D$

$r = \frac{1}{4}\ B.$

VALUES FOR JOHNSON'S FORMULA.

Column Material and How Supported.	S.	k.	Limit of $\frac{L'}{r'}$.
Mild Steel:			
Flat ends	52,500	2,148	16.3
Hinged ends . . .	52,500	2,640	13.3
Round ends . . .	52,500	3,408	10.3
Wrought Iron:			
Flat ends	42,000	1,536	18.2
Hinged ends . .	42,000	1,884	14.8
Round ends . . .	42,000	2,436	11.5
Cast Iron:			
Flat ends	80,000	5,256	10.2
Hinged ends . . .	80,000	6,444	8.3
Round ends . . .	80,000	8,316	6.4
Oak:			
Flat ends	5,400	336	10.7

STRENGTH OF WROUGHT IRON OR MILD STEEL COLUMNS.

By Johnson's Formula.

L in Ft. / r in In.	$52{,}500 - 2{,}700\frac{L}{r}$	$13{,}125 - 675\frac{L}{r}$	$10{,}500 - 540\frac{L}{r}$	$8{,}750 - 450\frac{L}{r}$
$\frac{L}{r}$	Ultimate Unit Stress.	Safe Unit Stress Factor = 4.	Safe Unit Stress Factor = 5.	Safe Unit Stress Factor = 6.
1.00	49,800	12,450	9,960	8,300
1.25	49,125	12,281	9,825	8,187
1.50	48,450	12,112	9,690	8,075
1.75	47,775	11,944	9,555	7,963
2.00	47,100	11,775	9,420	7,850
2.25	46,425	11,606	9,285	7,737
2.50	45,750	11,437	9,150	7,625
2.75	45,075	11,269	9,015	7,513
3.00	44,400	11,000	8,880	7,400
3.25	43,725	10,931	8,745	7,287
3.50	43,050	10,762	8,610	7,175
3.75	42,375	10,594	8,475	7,063
4.00	41,700	10,425	8,340	6,950
4.25	41,025	10,256	8,205	6,837
4.50	40,350	10,087	8,070	6,725
4.75	39,675	9,919	7,935	6,612
5.00	39,000	9,750	7,800	6,500
5.25	38,325	9,581	7,665	6,387
5.50	37,650	9,412	7,530	6,275
5.75	36,975	9,244	7,395	6,162
6.00	36,300	9,075	7,260	6,050
6.25	35,625	8,906	7,125	5,937
6.50	34,950	8,737	6,990	5,825
6.75	34,275	8,569	6,855	5,712
7.00	33,600	8,400	6,720	5,600
7.25	32,925	8,231	6,585	5,487
7.50	32,250	8,062	6,450	5,375
7.75	31,575	7,894	6,315	5,262
8.00	30,900	7,725	6,180	5,150
8.25	30,225	7,556	6,045	5,037
8.50	29,550	7,387	5,910	4,925
8.75	28,875	7,219	5,775	4,812
9.00	28,200	7,050	5,640	4,700
9.25	27,525	6,881	5,505	4,587
9.50	26,850	6,712	5,370	4,475
9.75	26,175	6,544	5,235	4,362

STRENGTH OF WROUGHT IRON OR MILD STEEL COLUMNS. — *Continued.*

By Johnson's Formula.

L in Ft. r in In.	$52{,}500 - 2{,}700\frac{L}{r}$	$13{,}125 - 675\frac{L}{r}$	$10{,}500 - 540\frac{L}{r}$	$8{,}750 - 450\frac{L}{r}$
$\frac{L}{r}$	Ultimate Unit Stress.	Safe Unit Stress Factor = 4.	Safe Unit Stress Factor = 5.	Safe Unit Stress Factor = 6.
10.00	25,500	6,375	5,100	4,250
10.25	24,825	6,206	4,965	4,137
10.50	24,150	6,037	4,830	4,025
10.75	23,475	5,869	4,695	3,912
11.00	22,800	5,700	4,560	3,800
11.25	22,125	5,531	4,425	3,687
11.50	21,450	5,362	4,290	3,575
11.75	20,775	5,194	4,135	3,462
12.00	20,100	5,025	4,020	3,350
12.25	19,425	4,856	3,885	3,237
12.50	18,750	4,687	3,750	3,125
12.75	18.075	4,519	3,615	3,012
13.00	17,400	4,350	3,480	2,900
13.25	16,725	4,181	3,345	2,787
13.50	16,050	4,012	3,210	2,675
13.75	15,375	3,844	3,075	2,562
14.00	14,700	3,675	2,940	2,450
14.25	14,025	3,506	2,805	2,337
14.50	13,350	3,337	2,670	2,225
14.75	12,675	3,169	2,535	2,112
15.00	12,000	3,000	2,400	2,000
15.25	11,325	2,831	2,265	1,887
15.50	10,650	2,662	2,130	1,775
15.75	9,975	2,494	1,995	1,662
16.00	9,300	2,325	1,860	1,550
16.25	8,625	2,131	1,725	1,437
16.50	7,950	1,987	1,590	1,325
16.75	7,275	1,819	1,455	1,212
17.00	6,600	1,650	1,320	1,100
17.25	5,925	1,481	1,185	987
17.50	5,250	1,312	1,050	875
17.75	4,575	1,144	915	762
18.00	3,900	975	780	650
18.25	3,225	806	645	537
18.50	2,550	638	510	425
18.75	1,875	469	375	312

PIPE PILLARS.

Diameter, External.	Radii of Gyration $\frac{1}{4}\sqrt{D^2+d^2}$.									
	Thickness in Decimals of an Inch.									
	.1	.2	.3	.4	.5	.6	.7	.8	.9	1 In.
2″	.67	.64	.61	.58	.56	.54	.52	.51	.50	.50
3	1.03	.99	.96	.93	.90	.88	.85	.83	.81	.79
4	1.38	1.35	1.31	1.28	1.25	1.22	1.19	1.16	1.14	1.12
5	1.73	1.70	1.66	1.63	1.60	1.57	1.54	1.51	1.48	1.46
6	2.08	2.05	2.02	1.98	1.95	1.92	1.89	1.86	1.83	1.80
7	2.43	2.40	2.36	2.33	2.30	2.27	2.24	2.21	2.18	2.15
8	2.79	2.76	2.72	2.69	2.66	2.62	2.59	2.56	2.53	2.50
9	3.15	3.11	3.08	3.04	3.01	2.97	2.94	2.91	2.88	2.85
10	3.51	3.47	3.44	3.40	3.37	3.33	3.30	3.27	3.23	3.20
11	3.86	3.82	3.79	3.75	3.72	3.68	3.65	3.62	3.58	3.55
12	4.21	4.18	4.15	4.11	4.08	4.04	4.01	3.97	3.94	3.90

STANDARD PIPE ELEMENTS.

STANDARD STRENGTH PIPES.								
Nominal Size.	Outside Diameter.	Inside Diameter.	Sq. In. Internal Area.	Sq. In. of Metal.	Moment of Inertia.	Resistance, $\frac{I}{Y}$.	Radii of Gyration, R^2.	Weight per Foot in Pounds.
⅛	.405	.27	.0573	.0717	.001032	.005195	.014808	.241
¼	.54	.364	.1041	.1249	.003312	.012267	.026508	.42
⅜	.675	.494	.1917	.1663	.007267	.02153	.043716	.559
½	.84	.623	.3048	.2492	.017045	.04058	.068358	.837
¾	1.05	.824	.5333	.3327	.037035	.07054	.111342	1.115
1	1.315	1.048	.8626	.4954	.10665	.1622	.1176721	1.668
1¼	1.66	1.38	1.496	.668	.1947	.2345	.29125	2.244
1½	1.9	1.611	2.038	.797	.3091	.3254	.46283	2.678
2	2.375	2.067	3.356	1.074	.666	.5609	.61957	3.608
2½	2.875	2.468	4.784	1.708	1.532	1.0657	.89729	5.739
3	3.5	3.067	7.388	2.243	3.023	1.7274	1.3535	7.536
3½	4	3.548	9.887	2.679	4.788	2.394	1.7868	9.001
4	4.5	4.026	12.73	3.174	7.23	3.213	2.2787	10.66
4½	5	4.508	15.96	3.674	10.41	4.164	2.8326	12.34
5	5.563	5.045	19.99	4.316	15.21	5.468	3.5226	14.50
6	6.625	6.065	28.89	5.584	28.17	8.504	5.0422	18.76
7	7.625	7.023	38.74	6.926	46.5	12.197	6.7165	23.27
8	8.625	7.982	50.04	8.386	72.35	16.777	8.6314	28.18
9	9.625	8.937	62.73	10.03	108.2	22.483	10.782	33.70
10	10.75	10.019	78.84	11.92	160.9	29.935	13.496	40.06
11	12	11.25	99.40	13.70	231.7	38.617	16.910	45.95
12	12.75	12	113.1	14.58	279	42.765	19.160	48.98
13	14	13.25	137.9	16.05	373	53.286	23.222	53.92
14	15	14.25	159.5	17.23	461	61.467	26.504	57.89
15	16	15.25	182.3	18.41	562	70.25	30.535	61.77

STANDARD PIPE ELEMENTS. — (*Continued.*)

	Nominal Size.	Outside Diameter.	Inside Diameter.	Sq. In. Internal Area.	Sq. In. of Metal.	Moment of Inertia	Resistance, $\frac{I}{Y}$.	Radii of Gyration, R^2.	Weight per Foot in Pounds.
EXTRA STRONG.	1/8	.405	.205	.033	.036	.001234	.00609	.01288	.29
	1/4	.54	.294	.068	.161	.003807	.01410	.02363	.54
	3/8	.675	.425	.139	219	.008588	.02545	.03977	.74
	1/2	.84	.542	.231	.323	.020204	.04811	.06246	1.09
	3/4	1.05	.736	.452	.414	.045261	.08621	.10276	1.39
	1	1.315	.951	71	.048	.10665	.16220	.16466	2.17
	1 1/4	1,66	1.272	1.271	.893	.2442	.27012	.27329	3
	1 1/2	1.9	1.494	1.753	1.082	.3952	.41631	.36513	3.63
	2	2.375	1.933	2.935	1 495	.8767	.73827	.58607	5.02
	2 1/2	2.875	2.315	4.209	2.283	1.9434	1.3522	.85155	7.67
	3	3.5	2.892	6.569	3.052	3.932	2.2771	1,2884	10.25
	3 1/2	4	3.358	8.856	3.71	6.325	3.1625	1.7048	12.47
	4	4.5	3.818	11.449	4.445	9.72	4.3200	2.1767	14.97
	5	5.563	4.813	18.19	6.12	20.67	7.4312	3.[illegible]	20.34
	6	6.625	5.75	25.97	8.505	40.93	12.356	4.8096	28.58
DOUBLE EXTRA STRONG.	1/2	.84	.244	.047	.507	.024266	.05777	.04782	1 7
	3/4	1.05	.422	.139	.727	.058098	.11066	[illegible]	2.44
	1	1.315	.587	.271	1.087	.14097	.2144	.12961	3.65
	1 1/4	1.66	.885	.615	1.549	.3426	.4128	.22115	5.2
	1 1/2	1.9	1.088	.93	1.905	.57092	.6010	.29961	6.4
	2	2.375	1.491	1.744	2.686	1.3194	1.1117	.49148	9.02
	2 1/2	2.875	1.755	2.419	4.073	2.8873	2.0085	.70910	13.68
	3	3.5	2.284	4.097	5.524	6.030	3.4457	1.0916	18.56
	3 1/2	4	2.716	5.794	6.772	9.895	4.9475	1 4610	22.75
	4	4.5	3.136	7.724	8.18	15.38	6.8355	1.8803	27 48
	5	5.563	4.063	12.965	11.34	33.63	12.0906	2.9630	38.12
	6	6.625	4.875	18.666	15.896	66.87	20.1872	4.2285	53.11

STEEL COLUMNS.

Size of Column.	Condition of Ends.	Length in Feet. 2	4	6	8	10	12	14	16	18
		Greatest Safe Load in Pounds per Sq. In. of Section.								
12 ins.	Fixed	23,000	23,000	23,000	20,920	17,060	15,570	14,630	14,030	13,590
diameter,	Flat	23,000	23,000	23,000	20,920	17,060	15,570	14,630	14,030	13,590
½″ thick,	Hinged	23,000	23,000	23,000	20,140	16,390	14,810	13,810	13,090	12,580
$R = 4.03$.	Round	23,000	23,000	23,000	18,760	15,200	13,670	12,460	11,500	10,880
10 ins.	Fixed	23,000	23,000	22,810	17,780	15,570	14,500	13,870	13,260	12,500
diameter,	Flat	23,000	23,000	22,810	17,780	15,570	14,500	13,870	13,260	12,500
½″ thick,	Hinged	23,000	23,000	22,030	17,040	14,830	13,600	12,880	12,280	11,460
$R = 3.37$.	Round	23,000	23,000	20,960	15,780	13,090	12,280	11,340	10,470	9,580
8 ins.	Fixed	23,000	23,000	18,600	16,490	14,250	13,550	12,570	11,690	10,900
diameter,	Flat	23,000	23,000	18,600	15,490	14,250	13,550	12,570	11,690	10,900
½″ thick,	Hinged	23,000	23,000	17,850	14,740	13,350	12,540	11,560	10,630	9,670
$R = 2.66$.	Round	23,000	23,000	16,480	13,590	11,910	10,820	9,690	8,620	7,650
6 ins.	Fixed	23,000	20,770	15,510	14,000	12,670	11,700	10,670	9,720	8,960
diameter,	Flat	23,000	20,770	15,510	14,000	12,670	11,700	10,660	9,670	8,730
½″ thick,	Hinged	23,000	19,990	14,760	13,060	11,880	10,050	9,390	8,190	7,200
$R = 2.00$.	Round	23,000	18,650	13,610	11,540	10,040	8,640	7,350	6,110	5,140
5 ins.	Fixed	23,000	17,350	14,370	13,060	11,000	10,360	9,280	8,500	7,590
diameter,	Flat	23,000	17,350	14,370	13,000	11,600	10,340	9,180	8,070	7,050
½″ thick,	Hinged	23,000	16,630	13,500	12,080	10,520	9,000	7,620	6,560	5,550
$R = 1.64$.	Round	23,000	15,430	12,090	10,270	8,500	6,940	5,550	4,510	3,560
4 ins.	Fixed	23,000	15,490	13,550	11,690	10,170	8,970	7,940	6,830	5,910
diameter,	Flat	23,000	15,490	13,550	11,090	10,140	8,710	7,420	6,220	5,120
½″ thick,	Hinged	23,000	14,740	12,540	10,630	8,700	7,180	5,920	4,710	3,560
$R = 1.33$.	Round	23,000	13,590	10,820	8,610	6,690	5,120	3,900	2,850	2,040
3 ins.	Fixed	20,770	14,000	11,700	9,720	8,350	6,850	5,590	4,280	3,300
diameter,	Flat	20,770	14,000	11,700	9,670	7,850	6,250	4,700	3,560	2,780
⅜″ thick,	Hinged	19,990	13,060	10,650	8,190	6,350	4,740	3,250	2,230	1,620
$R = 1.00$.	Round	18,650	11,540	8,640	6,110	4,310	2,860	1,880	1,270	910
2 ins.	Fixed	15,450	11,640	8,920	6,760	4,810	3,230	2,290	1,760	. . .
diameter,	Flat	15,450	11,640	8,650	6,150	4,040	2,730	2,020	1,450	. . .
½″ thick,	Hinged	14,700	10,570	7,130	4,640	2,580	1,580	1,000	790	. . .
$R = 0.66$.	Round	13,530	8,560	5,000	2,790	1,510	890	630	450	. . .

STEEL COLUMNS. — *Continued.*

Size of Column.	Condition of Ends.	Length in Feet.								
		20	22	24	26	28	30	32	34	36
		Greatest Safe Load in Pounds per Sq. In. of Section.								
12 ins. diameter, [illegible]″ thick, $R = 4.03$.	Fixed	12,930	12,350	11,750	11,280	10,730	10,240	9,770	9,340	9,020
	Flat	12,930	12,350	11,750	11,230	10,710	10,220	9,730	9,200	8,800
	Hinged	11,940	11,310	10,700	10,060	9,450	8,850	8,200	7,710	7,260
	Round	10,110	9,400	8,690	8,070	7,410	6,770	6,180	5,630	5,200
10 ins. diameter, [illegible]″ thick, $R = 3.37$.	Fixed	11,770	11,150	10,550	9,980	9,430	9,040	8,670	8,280	7,820
	Flat	11,770	11,150	10,540	9,950	9,370	8,830	8,090	7,780	7,290
	Hinged	10,730	9,990	9,230	8,520	7,830	7,300	6,770	6,270	5,790
	Round	8,720	7,960	7,180	6,450	5,750	5,230	4,730	4,240	3,780
8 ins. diameter, [illegible]″ thick, $R = 2.66$.	Fixed	10,170	9,460	8,970	8,490	7,940	7,350	6,830	6,380	5,910
	Flat	10,130	9,410	8,710	8,050	7,420	6,810	6,220	5,690	5,120
	Hinged	8,760	7,870	7,180	6,540	5,920	5,310	4,710	4,110	3,560
	Round	6,690	5,790	5,120	4,500	3,900	3,340	2,850	2,420	2,040
6 ins. diameter, [illegible]″ thick, $R = 2.00$.	Fixed	8,350	7,570	6,850	6,250	5,590	4,910	4,280	3,760	3,300
	Flat	7,850	7,030	6,250	5,500	4,790	4,120	3,560	3,130	2,780
	Hinged	6,350	5,530	4,740	3,940	3,250	2,640	2,220	1,910	1,620
	Round	4,310	3,540	2,860	2,300	1,880	1,550	1,270	1,060	910
5 ins. diameter, [illegible]″ thick, $R = 1.64$.	Fixed	6,730	5,990	5,160	4,350	3,720	3,180	2,800	2,430	2,110
	Flat	6,100	5,200	4,370	3,630	3,100	2,700	2,390	2,120	1,870
	Hinged	4,590	3,630	2,860	2,280	1,890	1,550	1,320	1,160	1,000
	Round	2,750	2,080	1.670	1,300	1,050	870	760	670	590
4 ins. diameter, [illegible]″ thick, $R = 1.33$.	Fixed	4,880	4,000	3,280	2,790	2,330	2,010	1,790	. . .	. . .
	Flat	4,100	3,310	2,760	2,380	2,050	1,760	1,480	. . .	. . .
	Hinged	2,620	2,050	1,610	1,320	1,110	940	800	. . .	. . .
	Round	1,540	1,160	910	760	650	550	460	. . .	. . .
3 ins. diameter, [illegible]″ thick, $R = 1.00$.	Fixed	2,650	2,100	1,800	. . .	. . .	. . .	. . .	. . .	. . .
	Flat	2,280	1,860	1,490	. . .	. . .	. . .	. . .	. . .	. . .
	Hinged	1,250	1,000	810	. . .	. . .	. . .	. . .	. . .	. . .
	Round	720	580	460	. . .	. . .	. . .	. . .	. . .	. . .
2 ins. diameter, [illegible]″ thick, $R = 0.66$.	Fixed	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
	Flat	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
	Hinged	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
	Round	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .

STRENGTH OF METALS AND ALLOYS.

(Stresses given in Pounds per Square Inch.)

Metal.	Ultimate Resistance to Tension.	Ultimate Resistance to Compression.	Resistance to Bending.	Elastic Limit.	Coefficient of Elasticity. (Millions.)	Weight in Pounds per Cubic Inch.
Aluminium Bronze·						
10% Al, 90% Cu (rolled)	100,000	. . . .	. . .	60,000	18.0	.282
$1\frac{1}{4}$% Al, $98\frac{3}{4}$% Cu (cast)	26,800	. . . .	. . .	. . .	. . .	. . .
Brass and Bronze:						
Copper Tin Zinc						
85 15 — . .	35,500	95,000	63,000	20,000	. . .	.319
90 10 — . .	33,000	75,000	52,000	. . .	14 0	.318
95 5 — . .	30,000	52,000	39,000	16,000	13.7	.317
90 — 10 . .	30,000	48,000	24,000	. . .	. . .	.322
80 — 20 . .	37,000	65,000	30,000	10,000	12 4	.316
70 — 30 . .	43,000	79,000	36,000	9,100	14.0	.310
60 — 40 . .	49,000	75,000	42,000	16,400	12.2	.308
50 50 . .	24,000	117,400	48,000	16,900	11.6	.304
86 12 2 {Gun-Metal.	34,500	. . . .	62,400	. . .	12.5	.315
70 10 20 . .	31,760	. . . .	43,500	. . .	14 5	. . .
60 10 30 . .	21,500	. . . .	30,200	. . .	15 8	. . .
55 $\frac{1}{2}$ $44\frac{1}{2}$ . .	68,900	. . . .	. . .	22,000	. . .	. . .
Bronze, Manganese (cast)	71,200	130,000	. . .	17,700	. . .	. . .
" " (rolled	100,000	. . . .	. . .	80,000	. . .	. . .
" Phosphor . .	47,700	. . . .	. . .	21,500	. . .	. . .
" Tobin (rolled)	79,400	175,000	41,000	55,400	. . .	.296
Copper (cast) . . .	24,800	. . . .	. . .	8,000	18.0	. . .
" (sheet) . . .	32,000	. . . .	. . .	. . .	. . .	. . .
" wire annealed .	39,800	. . . .	. . .	25,000	18.0	. . .
Iron Cast (average) .	17,000	100,000	. . .	6,000	15 0	.26
" Wire annealed .	45,000	. . . .	. . .	. . .	. . .	. . .
" " hard drawn	75,000	. . . .	. . .	27,000	26 0	. . .
" Wrgt., rolled bars	50,000	36,000	. . .	30,000	29.0	. . .
" " " plates	50,000	. . . .	. . .	30,000	29 0	. . .
Lead	2,050	7,350	. . .	1,100	0.85	. . .
Steel (mild)	67,200	. . . .	. . .	35,000	29 00	. . .
Tin	3,500	6,400	. . .	1,670	4 6	. . .
Zinc (cast)	5,400	. . . .	. . .	4,050	. . .	. . .

PHYSICAL PROPERTIES OF TIMBER.

The physical properties of timber, given hereafter, are derived largely from the recent experiments of the Forestry Division, United States Department of Agriculture, which form the most complete and systematic series on record. The following general conclusions seem to be demonstrated:

1. That bleeding (the experiments were made on long-leaf yellow pine) has no material effect on the strength of timber, the flexibility is slightly increased, but the bled timber will probably endure exposure to the weather as well as the other.

2. That moisture reduces the strength of timber, whether that moisture be the sap, or water absorbed after seasoning. In general, seasoned timber, or with not more than 12 per cent. moisture, is from 75 per cent. to 100 per cent. stronger than green timber.

3. When artificially dried, timber contains a uniform percentage of moisture throughout, a condition requiring months or even years to attain in air-dried heavy timber.

When kiln-dried at usual temperatures, wood shows no loss of strength compared with air-dried timber of the same percentage of moisture. The effect of very high temperatures and pressures (as used in vulcanizing) is lower strengths than when air-dried.

4. Large timbers are equal in strength per square inch of section, tested every way, to small timbers, provided they are equally sound and contain the same percentage of moisture.

5. The tests seem to indicate that the strength of woods of uniform structure increases with the specific gravity irrespective of species; *i.e.*, in general, the heaviest wood is the strongest. Oak seems not to belong to the list of woods to which this general remark applies.

The data on properties of timbers must be used with considerable judgment and caution. Seasoned wood will gain weight, to the extent of 5 to 15 per cent., if exposed to the weather, and this excess will be reduced if the wood is kept a week in a warm dry place. Some of the individual tests made by the United States Forestry Division varied considerably from the mean values given in the table. In the case of tension tests, which varied most from the average, a few were as low as 25 per cent., while others reached 190 per cent. of the mean. The elastic limit given in connection with the data from the United States Forestry Division is the relative elastic limit suggested by Professor Johnson, as there is no definite "elastic limit" in timber similar to that in some metals. This relative elastic limit is taken where the rate of deflection is 50 per cent. more than it is under initial loads.

Modulus of ultimate bending is extreme fibre stress on beam at rupture. The modulus of elastic bending is the fibre stress when the rate of deflection is increased 50 per cent. The modulus of elasticity is derived from transverse tests.

STRENGTH

Seasoned timber, moisture 12 per cent and

Name of Material.	Ultimate Resistance to Tension.	Ultimate Resistance to Compression Length.	Ultimate Resistance to Compression. Cross.	Ultimate Resistance to Shear Length.	Ultimate Resistance to Shear. Cross.
Ash (American)	17,000	7,200	1,900	1,100	6,280
Birch	15,000	8,000	. . .	. . .	5,600
Box	20,000	10,300	. . .	. . .	. . .
Cedar (White)	. . .	5,200	700	400	1,370
Cedar (American Red)	10,800	6,000	. . .	. . .	. . .
Chestnut	11,500	5,300	. . .	. . .	1,530
Cottonwood (see Poplar)	. . .	. . .	. . .	. . .	. . .
Douglas Spruce (Oregon Pine)	13,000	5,700	800	500	. . .
Fir	13,000	. . .	. . .	1,300	. . .
Gum	. . .	7,100	1,400	800	5,890
Hemlock	8,700	5,700	. . .	400	2,750
Hickory (American) average	19,600	9,500	2,700	1,100	6,000
Lignum Vitæ	11,800	9,900	. . .	. . .	. . .
Mahogany (Spanish)	14,900	8,200	. . .	. . .	. . .
Maple	11,150	7,150	1,800	500	6,350
Oregon Pine (see Douglas Spruce)	. . .	. . .	. . .	. . .	. . .
Oak (Red)	10,250	7,200	2,300	1,100	. . .
Oak (Black or Yellow)	10,000	7,300	1,800	1,100	. . .
Oak (White)	13,600	8,500	2,200	1,000	4,400
Oak (Live)	. . .	10,400	. . .	. . .	8,480
Pine (Southern Yellow, long leafed)	13,000	8,000	1,260	835	5,600
Pine (Cuban)	13,000	8,700	1,200	770	. . .
Pine (Loblolly)	13,000	7,400	1,150	800	. . .
Pine (White)	10,000	5,400	700	400	2,500
Poplar	7,000	5,000	. . .	. . .	. . .
Spruce (Northern)	11,000	6,000	. . .	400	3,250
Spruce Pine (Pinus glabra of So. States)	12,000	7,300	1,200	800	. . .
Walnut (Black)	10,500	7,500	2,500	. . .	4,700

	Weight in Pounds per
Cherry	42 0
Cork	15.6
Ebony	76.1

OF TIMBER.

under. Stresses given in pounds per square inch.

Elastic Limit.	Modulus of Elasticity.	Modulus of Ultimate Bending.	Modulus of Elastic Bending.	Ordinary Working Stress. Tens.	Comp.	Trans.	Weight in Pounds per Cubic Foot.
7,900	1,640,000	10,800	7,900	2,000	1,000	1,200	39
....	1,645,000	11,700	....	2,000	1,000	1,200	33
....	......	....	....	2,500	1,200	1,500	..
5,800	910,000	6,300	5,800	1,200	600	800	23
....	......	7,200	....	1,400	700	900	..
....	1,140,000	8,100	....	1,400	600	900	41
....	......	....	....	...	...	...	..
6,400	1,680,000	7,900	6,400	1,400	700	1,000	32
....	1,530,000	....	....	...	...	...	..
7,800	1,700,000	9,500	7,800	1,200	900	900	37
....	......	7,100	....	...	...	750	25
11,200	2,390,000	16,000	11,000	2,000	1,200	1,800	50
....	......	11,700	....	1,500	1,200	1,500	83
....	1,255,000	9,550	....	1,500	1,200	1,500	53
....	......	10,000	....	...	...	...	49
....	......	....	....	...	...	...	..
9,200	1,970,000	11,400	9,200	1,400	900	1,200	45
8,100	1,740,000	10,800	8,100	1,400	900	1,200	45
9,600	2,090,000	13,100	9,600	1,700	1,000	1,500	50
9,040	1,851,500	11,300	....	...	...	...	..
10,000	2,070,000	12,600	9,500	1,600	1,000	1,500	38
11,100	2,370,000	13,600	10,640	...	...	...	..
9,200	2,050,000	11,300	9,400	1,600	900	1,200	33
6,400	1,390,000	7,900	6,400	1,200	700	900	24
....	......	6,500	....	900	600	750	..
....	1,400,000	8,000	....	1,200	700	900	26
8,400	1,640,000	10,000	8,400	1,200	700	900	30
5,700	1,306,000	8,000	....	1,000	1,000	900	38

Cubic Foot of other Woods.

Elm	35
Mahogany (Honduras)	35
Sycamore	37

TABLE OF WEIGHT AND STRENGTH OF WIRE

Standard Wire Gauge.	Diameter.		Sectional Area.	Weight of		Approximate Length of 1 Cwt.	Breaking Strain if Tempered to 100 Tons to the Sq. In.
				100 Yards.	1 Mile.		
	In.	MM.	Sq. In.	Lbs.	Lbs.	Yds.	Lbs
7/0	.500	12.7	.1963	193.4	3,404	58	43,975
6/0	.464	11.8	.1691	166.5	2,930	67	37,854
5/0	.432	11.0	.1466	144.4	2,541	78	32,823
4/0	.400	10.2	.1257	123.8	2,179	91	28,144
3/0	.372	9.4	.1087	107.1	1,885	105	24,354
2/0	.348	8 8	.0951	93.7	1,649	120	21,302
0	.324	8.2	.0824	81.2	1,429	138	18,464
1	.300	7.6	.0707	69.6	1,225	161	15,831
2	.276	7.0	.0598	58 9	1,037	190	13,398
3	.252	6.4	.0499	49.1	864	228	11,169
4	232	5 9	.0423	41 6	732	269	9,467
5	.212	5.4	.0353	34 8	612	322	7,904
6	.192	4 9	.0290	28 5	502	393	6,486
7	.176	4 5	.0243	24 0	422	467	5,450
8	.160	4.1	.0201	19.8	348	566	4,503
9	.144	3.7	0163	16 0	282	700	3,648
10	.128	3.3	.0129	12.7	223	882	2,882
11	.116	3.0	.0106	10.4	183	1,077	2,368
12	.104	2.6	.0085	8 4	148	1,333	1,903
13	.092	2.3	.0066	6.5	114	1 723	1,489
14	.080	2 6	.0050	5.0	88	2,240	1,126
15	.072	1.8	.0041	4 1	70	2,800	912
16	.064	1.6	.0032	3 2	56	3,500	721
17	056	1.4	.0025	2.4	42	4,667	552
18	.048	1 2	0018	1 8	32	6,222	406
19	.040	1 0	.0013	1 2	21	9,333	281
20	.036	0.9	.0010	1 0	18	11,200	228

NOTES ON THE USE OF WIRE ROPE.

Degrees.	Inclination per Yard in Inches.	One Inch.	Gravity Due to Incline per Ton in Lbs.
1	0.63	57.29	39.08
2	1.26	28.63	78.18
3	1.88	19.09	117 24
4	2.51	14.29	156 26
5	3.15	11.42	195.24
6	3.78	9.51	234.14
7	4.42	8.14	272.98
8	5.06	7.11	311.74
9	5.70	6.31	350.40
10	6.34	5.67	388.97
11	6.99	5.14	427.41
12	7.65	4.70	465 71
13	8.31	4.33	503.88
14	8.97	4.01	541.90
15	9.64	3.73	579 75
16	10.32	3.48	617.43
17	11.00	3.27	654 90
18	11.69	3.07	692.20
19	12.39	2.90	729.27
20	13.10	2.74	766.12
21	13.82	2.60	802.74
22	14.54	2.47	839.12
23	15.27	2.35	875.23
24	16.02	2.24	911.09
25	16.78	2.14	946.66
26	17.54	2.05	981.94
27	18.34	1.96	1,016.93
28	19 14	1.88	1,051.61
29	19 95	1.80	1,085.97
30	20.78	1.73	1,120.00
31	21 62	1.66	1 153.68
32	22.49	1.60	1,187.02
33	23 37	1 54	1,219.99
34	24.28	1.48	1,252.58
35	25.20	1.42	1,284.81
36	26.16	1.37	1,316.62
37	27.12	1.32	1,348.05
38	28.12	1.28	1,379.07
39	29 14	1.23	1,409.67
40	30.21	1.19	1,439.84

For Vertical Winding at high speeds, one-tenth the breaking strain has been adopted as a safe working load ; it may, however, be increased to one-eighth, according to conditions of working. The gross weight hanging over the pulley (including rope) being considered the working load.

Hauling on Inclined Plane. — The working load is usually taken at one-sixth the breaking strain, and the following formula for ascertaining the load has been found from experience to give satisfactory results :

Plane, 800 yds. Load, 20 tons.
Maximum inclination 7 degs or 1 in 8.14.

	Cwts	Qrs.	Lbs.
Gravity of load, 20 tons × 272.98 lbs. per ton =	48	0	16
Friction of load, 20 tons × 20 lbs. per ton =	3	2	8
Gravity of rope, 800 yds. at 2 15 lbs., 1720 ÷ 8.14 =	1	3	15
Friction of rope, 1720 ÷ 20 =	0	3	1
2¼ Plough steel rope =	55	1	12

Uncoiling Wire Rope. A reel or turntable should be used to avoid "kinks" or sharp bends.

Lubrication of Ropes. Both winding and hauling ropes should be well oiled to prolong duration. The winding rope especially ought to have frequent applications of heavy-bodied hydro-carbon oil, which should be well rubbed into the interstices with a swab, as it is important that the inside of the rope should benefit as well as the outside by its application

N B. An unlubricated rope stood 16,000 bends before fracture, whilst the same rope lubricated stood 38,700.

PROOF OR TEST LOAD FOR CHAINS.

d = Diameter of Iron in Inches.

The Admiralty Rules are:

Test Load in Tons = $18d^2$ for Studded Links.
Test Load in Tons = $12d^2$ for Unstudded Links.

d.	$18d^2$.	$12d^2$.	d.	$18d^2$.	$12d^2$.	d.	$18d^2$.	$12d^2$.
1/4	...	.75	3/4	10.1	6.7	1 1/2	40.5	27.0
5/16	...	1.17	13/16	11.9	7.9	1 5/8	47.5	31.7
3/8	...	1.69	7/8	13.8	9.2	1 3/4	55.1	36.7
7/16	3.45	2.30	15/16	15.8	10.5	1 7/8	63.3	42.2
1/2	4.50	3.00	1	18.0	12.0	2	72.0	48.0
9/16	5.70	3.80	1 1/8	22.8	15.2	2 1/8	81.3	54.2
5/8	7.03	4.69	1 1/4	28.1	18.7	2 1/4	91.1	60.7
11/16	8.51	5.67	1 3/8	34.0	22.7	2 3/8	101.5	67.7

The practice at Elswick is to make the test load 10 per cent. higher than the Admiralty test load.

STRENGTH OF CHAIN CABLES (AMERICAN).

Diameter of Iron.	Breaking Stress of Iron in Lbs. per Sq. In.	Recommended Proof Load on Cable.		Admiralty Proof Load on Cable.		Probable Average Ultimate Strength on Cable.	
In		Lbs.	Tons.	Lbs.	Tons.	Lbs.	Tons.
1	55,596	33,840	15.11	40,320	18.00	71,172	31.77
1 1/16	55,073	37,820	16.88	45,517	20.32	79,544	35.51
1 1/8	54,589	42,053	18.77	51,030	22.78	88,445	39.48
1 3/16	54,138	46,468	20.74	56,857	25.38	97,731	43.63
1 1/4	53,716	51,084	22.81	63,000	28.12	107,440	47.96
1 5/16	53,317	55,903	24.96	69,457	31.01	117,577	52.49
1 3/8	52,941	60,920	27.20	76,230	34.03	128,129	57.20
1 7/16	52,584	66,138	29.53	83,317	37.20	139,103	62.10
1 1/2	52,245	71,550	31.94	90,720	40.50	150,485	67.18
1 9/16	51,922	77,159	34.45	98,437	43.95	162,283	72.45
1 5/8	51,613	82,956	37.03	106,470	47.53	174,475	77.89
1 11/16	51,317	88,947	39.71	114,817	51.26	187,075	83.52
1 3/4	51,033	95,128	42.47	123,480	55.12	200,074	89.32
1 13/16	50,760	101,499	45.31	132,457	59.13	213,475	95.30
1 7/8	50,498	108,058	48.24	141,750	63.28	227,271	101.46
1 15/16	50,245	114,806	51.25	151,357	67.57	241,463	107.80
2	50,000	121,737	54.35	161,280	72.00	256,040	114.30

STRENGTH OF SMALL CHAINS.

THE FOLLOWING RULES ARE BASED ON EXPERIMENTS CARRIED OUT BY PROF. H. S. HALE SHAW ON SMALL CHAINS.

LESS THAN $\frac{5}{16}''$

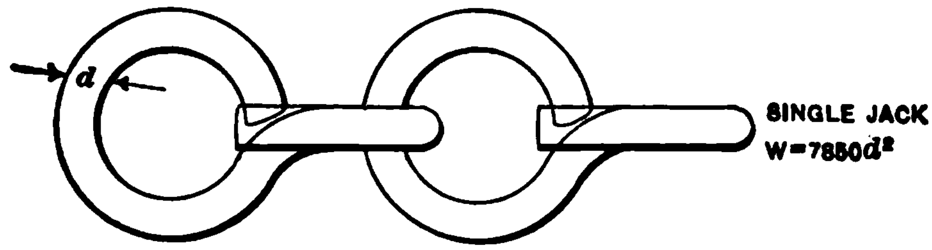


FIG. 102.

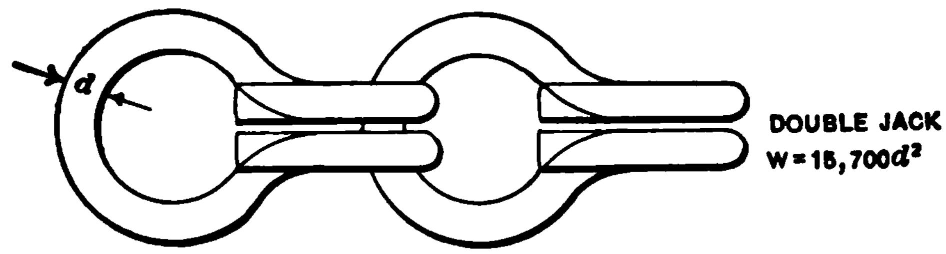


FIG. 103.

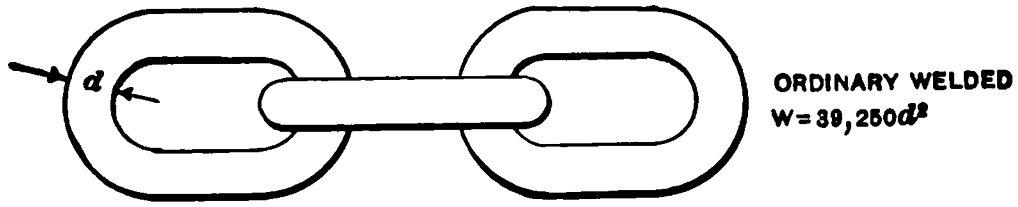
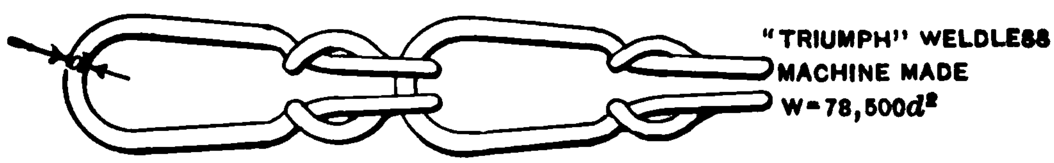


FIG. 104.



W=BREAKING LOAD IN LBS. D=SIZE OF CHAIN IN INCHES.
THE SAFE LOAD MAY BE TAKEN AS ONE QUARTER OF BREAKING LOAD.

FIG. 105.

DIMENSIONS AND WEIGHT OF CHAIN CABLES.*

Diameter of Iron.	Size of Links (Outside).		Number of Links in One Fathom.	Weight per Fathom.	
	Length.	Width.		Studded Links.	Open Links.
In.	In.	In.		Lbs.	Lbs.
1	5 11/16	3 9/16	19½	57.8	52.9
1 1/16	6 1/16	3 11/16	18½	64.7	60.1
1 1/8	6 1/4	4	18	77.7	69.7
1 3/16	6 5/8	4 1/8	17	84.8	77.4
1 1/4	7	4 7/16	16	94.9	86.8
1 5/16	7 5/16	4 9/16	15½	102.9	95.2
1 3/8	7 9/16	4 15/16	15	115.5	106.2
1 7/16	8	5 1/16	14	121.7	113.0
1 1/2	8 1/4	5 7/16	13½	134.3	124.2
1 9/16	8 11/16	5 9/16	13	144.6	134.9
1 5/8	9	5 7/8	12½	160.0	146.7
1 11/16	9 3/8	6	12	170.1	157.3
1 3/4	9 3/4	6 5/16	11½	183.2	168.9
1 13/16	10 3/16	6 7/16	11	192.9	179.1
1 7/8	10 5/16	6 3/4	11	215.6	199.1
1 15/16	10 3/4	6 7/8	10½	225.0	209.2
2	10 7/8	7 1/4	10	240.8	219.9
2 1/16	11 5/16	7 3/8	10	261.4	240.5
2 1/8	11 13/16	7 5/8	9½	272.1	250.7
2 3/16	12 3/4	7 3/4	9	279.1	258.8

ULTIMATE OR BREAKING STRENGTH OF CHAINS.

The breaking stress of the iron of which chains are made varies with the diameter of the bar, being less the greater the diameter.

If f = breaking stress of iron in tons per square inch,
and d = diameter of bar in inches,
then $f = 26.2 - 2.4\,d$.

Breaking load of chain in tons $= W = 1.22\,d^2\,(26.2 - 2.4\,d)$.

This formula allows for the bending action, and for the loss of strength due to the weld.

The following table gives values of W for various values of d, calculated by the above formula:

d	*W.*	*d.*	*W.*	*d.*	*W.*	*d.*	*W.*
1/4	1.95	5/8	11.8	1	29.0	1 3/4	82.2
5/16	3.03	11/16	14.2	1 1/8	36.3	1 7/8	93.1
3/8	4.34	3/4	16.7	1 1/4	44.2	2	104.4
7/16	5.87	13/16	19.5	1 3/8	52.8	2 1/8	116.2
1/2	7.62	7/8	22.5	1 1/2	62.0	2 1/4	128.5
9/16	9.59	15/16	25.7	1 5/8	71.8	2 3/8	141.1

* *From Report of* Committee of Government Board, U. S. A., 1879.

CHAPTER III.

ELEMENTS OF ANGLES.

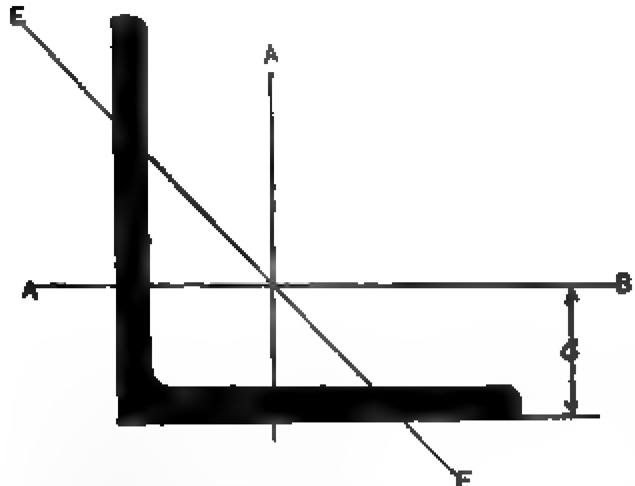


Fig. 106.

Size in Inches.	Thickness.	Area in Square Inches.	Weight per Foot in Pounds.	Moments of Inertia. Axis, *AB*.	Axis, *EF*.
8×8	$\frac{1}{2}$	7.75	26.4	48.47	19.60
$8\frac{1}{2} \times 8\frac{1}{2}$	1	15.29	52.8	94.14	39.01
6×6	$\frac{3}{8}$	4.36	14.8	15.37	6.20
$6\frac{1}{2} \times 6\frac{1}{2}$	$\frac{15}{16}$	10.65	35.9	36.69	15.48
5×5	$\frac{3}{8}$	3.61	12.3	8.73	3.54
$5\frac{1}{2} \times 5\frac{1}{2}$	$\frac{15}{16}$	8.77	29.4	20.72	[illegible]
4×4	$\frac{5}{16}$	2.40	8.2	3.69	1.50
$4\frac{1}{2} \times 4\frac{1}{2}$	$\frac{3}{4}$	5.69	18.6	8.71	3.82
$3\frac{1}{2} \times 3\frac{1}{2}$	$\frac{5}{16}$	2.09	7.1	2.45	0.99
$3\frac{1}{2} \times 3\frac{1}{2}$	$\frac{5}{8}$	4.06	13.7	4.60	1.97
3×3	$\frac{1}{4}$	1.44	4.9	1.25	0.50
$3\frac{5}{16} \times 3\frac{5}{16}$	$\frac{5}{8}$	3.51	11.5	3.01	1.32
$2\frac{3}{4} \times 2\frac{3}{4}$	$\frac{1}{4}$	1.31	4.5	0.95	0.39
3×3	$\frac{1}{2}$	2.70	8.6	2.11	0.90
$2\frac{1}{2} \times 2\frac{1}{2}$	$\frac{3}{16}$	0.90	3.1	0.54	0.22
$2\frac{1}{2} \times 2\frac{1}{2}$	$\frac{1}{2}$	2.33	7.8	1.33	0.59
$2\frac{1}{4} \times 2\frac{1}{4}$	$\frac{3}{16}$	0.81	2.7	0.39	0.16
$2\frac{1}{16} \times 2\frac{1}{16}$	$\frac{1}{2}$	1.66	5.4	0.85	0.37
2×2	$\frac{3}{16}$	0.71	2.5	0.27	0.11
$2\frac{5}{16} \times 2\frac{5}{16}$	$\frac{3}{8}$	1.47	4.8	0.61	0.26
$1\frac{3}{4} \times 1\frac{3}{4}$	$\frac{3}{16}$	0.62	2.1	0.18	0.08
$1\frac{11}{16} \times 1\frac{11}{16}$	$\frac{7}{16}$	1.28	4.1	0.39	0.18
$1\frac{1}{2} \times 1\frac{1}{2}$	$\frac{1}{8}$	0.36	1.2	0.08	0.03
$1\frac{1}{2} \times 1\frac{1}{2}$	$\frac{7}{16}$	1.14	3.5	0.29	0.13
$1\frac{1}{4} \times 1\frac{1}{4}$	$\frac{1}{8}$	0.30	1.0	0.05	0.02
$1\frac{1}{4} \times 1\frac{1}{4}$	$\frac{1}{4}$	0.62	2.0	0.10	0.04
1×1	$\frac{1}{8}$	0.23	0.8	0.02	0.01
$1\frac{1}{4} \times 1\frac{1}{4}$	$\frac{3}{16}$	0.49	1.5	0.05	[illegible]

ELEMENTS OF ANGLES.

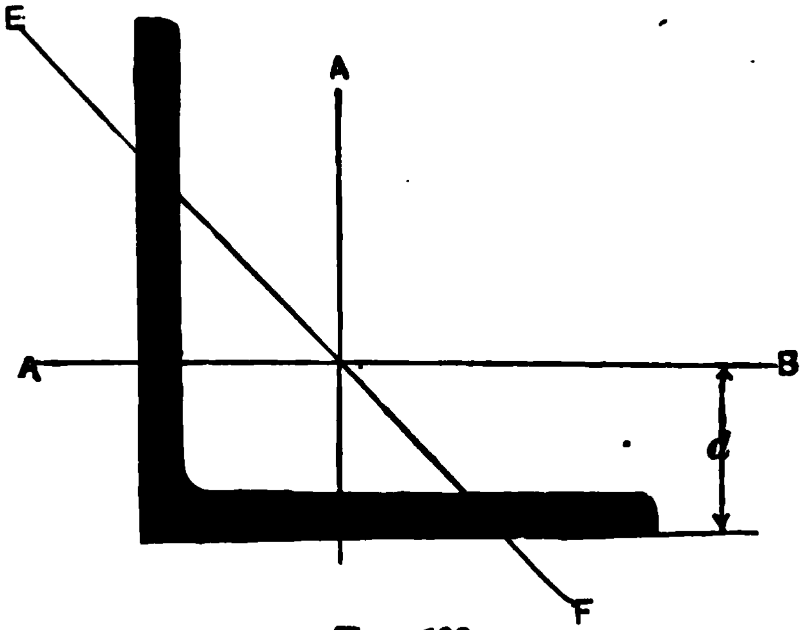


FIG. 106.

Radii of Gyration.		Resistance.	Distance from Base to Neutral Axis.
Axis *AB*.	Axis *EF*.	Axis *AB*.	*d*.
2.50	1.59	8.34	2.19
2.48	1.60	16.18	2.43
1.88	1.19	3.53	1.64
1.86	1.21	8.43	1.19
1.56	0.99	2.42	1.39
1.54	1.02	5.76	1.65
1.24	0.79	1.28	1.12
1.24	0.82	3.10	1.34
1.08	0.69	0.98	0.99
1.06	0.70	1.84	1.13
0.93	0.59	0.58	0.84
0.93	0.61	1.39	1.02
0.85	0.55	0.48	0.78
0.88	0.58	1.02	0.93
0.77	0.49	0.80	0.70
0.76	0.50	0.75	0.84
0.69	0.44	0.24	0.63
0.72	0.47	0.50	0.75
0.62	0.39	0.19	0.58
0.64	0.42	0.40	0.68
0.54	0.36	0.15	0.51
0.55	0.38	0.30	0.63
0.47	0.28	0.07	0.42
0.50	0.34	0.25	0.57
0.41	0.26	0.06	0.35
0.40	0.25	0.11	0.43
0.29	0.21	0.03	0.30
0.32	0.20	0.07	0.37

ELEMENTS OF BULB ANGLES.

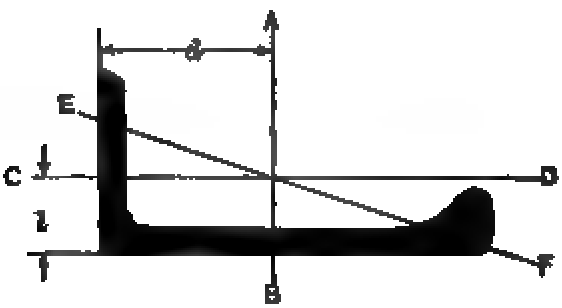


Fig. 107.

Size in Inches.	Area in Square Inches.	Weight per Foot in Pounds.	Moments of Inertia.			Square of Radius of Gyration.			Radius of Gyration.		
			Axis *AB.*	Axis *CD.*	Axis *EF.*	Axis *AB.*	Axis *CD.*	Axis *EF*	Axis *AB.*	Axis *CD.*	Axis *EF.*
10	7.70	26.2	94.17	7.11	5.22	12 23	0.92	0.68	3.50	0 96	0.82
10	11 24	38.2	136.41	11 93	9.19	12 14	1.06	0.82	3.48	1 03	0.90
9	6.74	22.9	67 67	6.58	4.68	10 04	0.98	0.69	3.17	0.99	0.83
9	9.56	32.5	95.71	10.61	7.60	10.01	1 11	0.79	3.16	1.05	0.89
8	5.62	19.1	44.69	4 09	3.06	7.95	0.73	0.54	2.82	0.85	0.74
8	7.77	26.4	61.63	6.43	4.83	7.93	0.83	0.62	2.82	0.91	0.79
7	4 79	16.3	29.74	3.73	2 66	6.21	0 78	0.56	2.49	0.88	0.75
7	6.41	21.8	39 67	5.58	3.93	6.19	0.87	0.61	2.49	0.93	0.78
6	3 91	13 3	18.31	3.24	2.26	4 68	0.83	0.58	2 16	0.91	0.76
6	5.24	17.8	24.35	4.81	3.29	4 65	0.92	0.63	2.16	0.96	0.79
5	2.97	10 1	9.84	1.76	1.52	3.31	0.59	0.51	1.82	0.77	0.72
5	3.97	13.5	13.07	2.64	1 86	3.29	0.66	0.47	1.81	0.82	0.68

ELEMENTS OF DECK BEAMS.

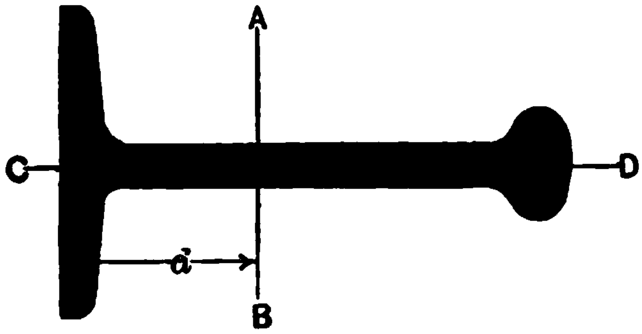


FIG. 108.

Size in Inches.	Area in Square Inches.	Weight per Foot in Lbs.	Moments of Inertia.		Square of Radius of Gyration.		Radius of Gyration.	
			Axis *AB.*	Axis *CD.*	Axis *AB.*	Axis *CD.*	Axis *AB.*	Axis *CD.*
11½	9.51	32.2	179.33	6.36	18.86	0.67	4.34	0.82
11½	13.41	45.6	224.19	8.14	16.72	0.61	4.09	0.78
10	8.20	28.0	118.55	6.08	14.46	0.74	3.80	0.86
10	11.32	38.6	145.77	7.54	12.88	0.67	3.59	0.82
9	7.35	25.0	84.99	4.85	11.56	0.66	3.40	0.81
9	9.60	32.6	100.68	5.78	10.49	0.60	3.24	0.77
8	6.17	21.0	57.75	3.58	9.36	0.58	3.06	0.76
8	8.43	28.6	70.19	4.44	8.33	0.53	2.89	0.73
7	5.32	18.0	36.99	2.56	6.95	0.48	2.64	0.69
7	7.29	24.5	45.32	3.26	6.22	0.45	2.49	0.67
6	4.27	14.5	21.83	1.62	5.11	0.38	2.26	0.62
6	5.77	19.6	26.50	2.07	4.59	0.36	2.14	0.60
5	3.39	11.5	11.96	1.01	3.53	0.30	1.88	0.55
5	4.64	15.8	14.64	1.29	3.16	0.28	1.78	0.53

ELEMENTS OF DECK BEAMS.—*(Continued.)*

Size in Inches.	Resistance, Axis *AB*.	Add to Resistance for each Additional Pound per Foot.	Coefficient Greatest Safe Load in Net Tons.	Add to previous Coefficient for Additional Pound per Ft	Coefficient for Deflection: Distributed Load.	Coefficient for Deflection: Centre Load.	Maximum Load in Net Tons	Distance *d* from Base to Neutral Axis.
11½	27.9	0.60	148.7	3.22	.0000089	.0000143	48.6	5.07
11½	36.0	0.60	191 9	3 22	.0000071	.0000114	119.4	5.27
10	20.7	0.54	110.5	2.86	.0000135	.0000217	40.8	4.28
10	26.4	0 54	140.8	2 86	.0000107	.0000172	96.4	4.48
9	16.7	0 48	88 9	2.55	.0000188	.0000303	39.0	3.90
9	20 3	0.48	108.3	2.55	.0000159	.0000256	79.0	4.04
8	12.8	0 43	68 1	2 28	0000277	.0000446	32.4	3.48
8	16.0	0.43	85 5	2.28	.0000228	.0000367	72.2	3.62
7	9.3	0.38	49 8	2.02	0000432	.0000695	30.2	3.04
7	11.8	0.38	62.9	2.02	.0000352	.0000568	64.6	3.16
6	6 4	0.32	34.3	1 69	0000733	.0001180	24.0	2.61
6	8.1	0 32	43.0	1.69	.0000604	.0000072	50.2	2.71
5	4 3	0.26	22.9	1.39	.0001337	.0002147	21.4	2.22
[illegible]	5.4	0 26	28.9	1.39	.0001098	.0001755	42.8	2.30

ELEMENTS OF TEES. — Uneven Legs.

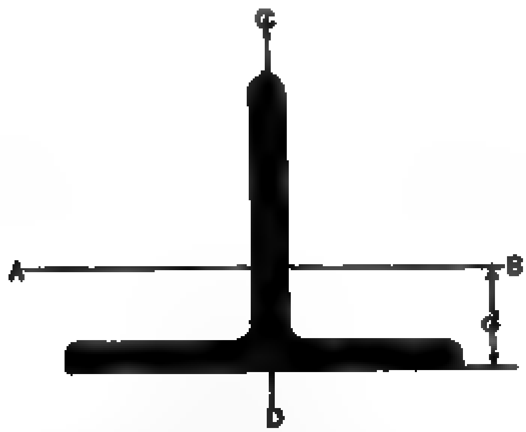


Fig. 109.

Size in Inches.	Area in Square Inches.	Wt. per Foot in Pounds.	Moments of Inertia. Axis AB.	Moments of Inertia. Axis CD.	Resistance. Axis AB.	Resistance. Axis CD.	Radius of Gyration. Axis AB.	Radius of Gyration. Axis CD.	Dist d from Base to N. Axis.
6 × 4½	8.21	28.2	14.74	13.81	4.71	4.60	1.33	1.29	1.37
6 × 4	4.61	15.6	5.82	8.19	1.92	2.73	1.12	1.33	0.97
6 × 5½	11.58	39.0	28.68	18.75	8.19	6.25	1.57	1.27	1.75
5 × 3½	4.95	17.0	5.29	5.47	2.17	2.19	1.03	1.05	1.06
5 × 4	4.54	15.3	6.16	5.41	2.11	2.16	1.17	1.09	1.08
4 × 2	1.93	6.5	0.53	1.75	0.34	0.87	0.52	0.95	0.46
4 × 3	2.67	9.0	1.99	2.10	0.90	1.05	0.87	0.89	0.78
4 × 3	3.05	10.2	2.24	2.44	1.02	1.22	0.86	0.89	0.81
4 × 4½	4.29	14.6	7.87	2.80	2.50	1.40	1.37	0.81	1.37
4½ × 3½	4.65	15.8	4.93	3.67	2.05	1.63	1.03	0.89	1.11
4 × 4½	3.33	11.4	6.31	2.11	1.96	1.06	1.37	0.79	1.28
3½ × 3	2.11	7.0	1.65	1.18	0.75	0.67	0.86	0.75	0.80
3½ × 3	2.46	8.5	1.91	1.41	0.88	0.81	0.88	0.75	0.83
3 × 1½	1.20	4.0	0.18	0.60	0.16	0.40	0.39	0.71	0.36
3 × 2½	1.46	5.0	0.78	0.60	0.42	0.40	0.73	0.64	0.66
3 × 2½	1.76	6.0	0.93	0.74	0.51	0.49	0.73	0.65	0.68
3 × 2½	2.06	7.0	1.08	0.89	0.60	0.59	0.72	0.66	0.71
3 × 2½	2.38	8.0	1.32	0.91	0.78	0.61	0.74	0.62	0.80
3 × 3½	2.46	8.3	2.82	0.89	1.17	0.59	1.07	0.60	1.06
3 × 3½	2.81	9.5	3.19	1.04	1.33	0.69	1.07	0.61	1.10
2¾ × 1½	1.96	6.6	0.56	0.60	0.50	0.44	0.54	0.56	0.64
2¾ × 2	2.14	7.2	0.82	0.61	0.06	0.44	0.62	0.54	0.75
2½ × 1½	0.97	3.3	0.10	0.33	0.11	0.26	0.32	0.58	0.31
2½ × 2½	1.68	5.7	1.16	0.43	0.60	0.34	0.83	0.51	0.68
2½ × 3	1.76	6.0	1.48	0.44	0.71	0.35	0.92	0.50	0.93
2¼ × 9/16	0.66	2.2	0.01	0.24	0.03	0.21	0.14	0.60	0.17
2 × 9/16	0.60	2.0	0.01	0.17	0.03	0.17	0.14	0.53	0.17
2 × 1 1/16	0.62	2.0	0.04	0.16	0.05	0.16	0.24	0.51	0.23
2 × 1	0.72	2.5	0.05	0.17	0.07	0.17	0.26	0.49	0.27
2 × 1½	0.91	3.0	0.16	0.17	0.15	0.17	0.42	0.44	0.45
1¾ × 1 1/16	0.56	1.9	0.05	0.11	0.06	0.13	0.30	0.45	0.24
1¾ × 1½	1.04	3.5	0.12	0.21	0.14	0.24	0.35	0.45	0.40
[illegible]	0.41	1.4	0.02	0.07	0.08	0.09	0.22	0.41	0.21
[illegible]	0.35	1.2	20.0	0.03	0.03	0.05	0.24	0.30	0.22

ELEMENTS OF TEES. — Even Legs.

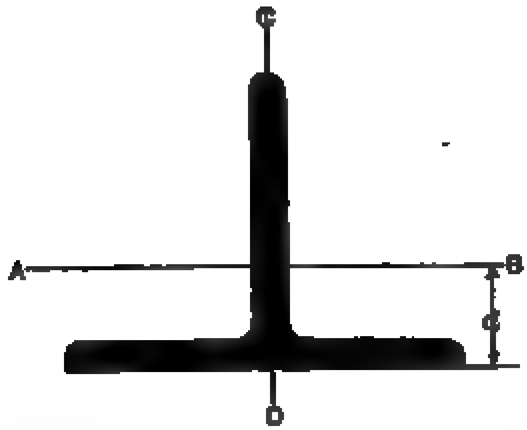


FIG. 109.

Size in Inches.	Area in Square Inches.	Weight per Foot in Pounds.	Moments of Inertia		Resistance.		Radius of Gyration.		Distance *d* from Base to N. Axis.
			Axis *AB.*	Axis *CD.*	Axis *AB.*	Axis *CD.*	Axis *AB.*	Axis *CD.*	
4 × 4	3.10	10.9	4.70	2.20	1.64	1.10	1.23	0.85	1.15
4 × 4	3.98	13.7	5.70	2.79	2.02	1.40	1.20	0.84	1.18
3½ × 3½	2.08	7.0	2.27	1.03	0.80	0.59	1.04	0.71	0.94
3½ × 3½	2.65	9.0	2.83	1.32	1.16	0.75	1.03	0.71	1.06
3½ × 3½	3.24	11.0	3.61	1.75	1.49	1.00	1.06	0.73	1.07
3 × 3	1.91	6.5	1.57	0.75	0.74	0.50	0.91	0.62	0.87
3 × 3	2.27	7.7	1.82	0.89	0.86	0.60	0.89	0.62	0.88
2½ × 2½	1.47	5.0	0.79	0.38	0.44	0.30	0.73	0.51	0.69
2½ × 2½	1.71	5.8	0.95	0.48	0.55	0.38	0.75	0.53	0.76
2½ × 2½	1.94	6.6	1.08	0.56	0.63	0.45	0.75	0.54	0.79
2¼ × 2¼	1.18	4.0	0.51	0.27	0.31	0.24	0.66	0.48	0.62
2¼ × 2¼	1.18	4.0	0.52	0.28	0.33	0.23	0.66	0.47	0.65
2 × 2	1.03	3.5	0.37	0.18	0.26	0.18	0.60	0.41	0.60
1¾ × 1¾	0.71	2.4	0.19	0.09	0.15	0.10	0.52	0.36	0.51
1½ × 1½	0.59	2.0	0.12	0.06	0.12	0.08	0.45	0.32	0.47
1¼ × 1¼	0.44	1.5	0.07	0.04	0.09	0.06	0.40	0.30	0.43
1 × 1	0.29	1.0	0.03	0.02	0.05	0.04	0.32	0.26	0.33

ELEMENTS OF Z BARS.

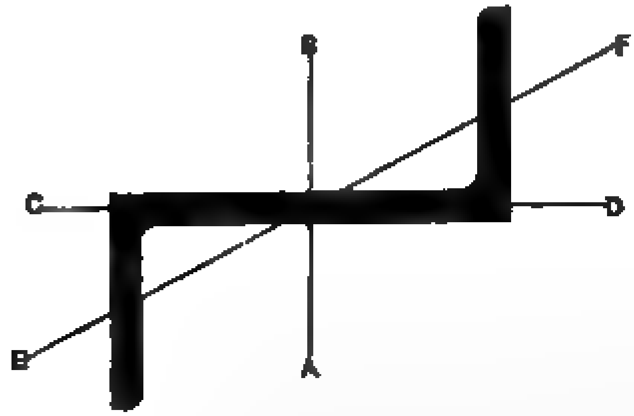


FIG. 116.

Sizes in Inches.	Area in Square Inches.	Weight per Foot in Pounds.	Moment of Inertia. Axis AB.	Moment of Inertia. Axis CD.	Moment of Inertia. Axis EF.	Resistance. Axis AB.	Resistance. Axis CD.
2 5/8 × 3 × 2 5/8 × 1/4	1 94	6.60	2.81	2.81	0.59	1.9	1.0
2 11/16 × 3 1/16 × 2 11/16 × 5/16	2.44	8.29	3.52	3.38	0.74	2.3	1.3
2 3/4 × 3 1/8 × 2 3/4 × 3/8	2.94	10.00	4.34	4.22	0.92	2.8	1 7
2 21/32 × 3 × 2 21/32 × 7/16	3.25	11.15	4.20	4.24	0.95	2.8	1.7
2 23/32 × 3 1/16 × 2 23/32 × 1/2	3.61	11.93	4.54	4 64	1.01	3.0	1.9
2 25/32 × 3 1/8 × 2 25/32 × 9/16	3.75	12.75	4.88	5.04	1.11	3 2	2.0
2 7/8 × 4 × 2 7/8 × 1/4	2.32	7.88	5.95	3.47	0.86	3.0	1.3
2 15/16 × 4 1/16 × 2 15/16 × 5/16	2.91	9.89	7.52	4.49	1.23	3.7	1.8
3 × 4 1/8 × 3 × 3/8	3.52	11.90	9.14	5.68	1 53	4.4	2.0
2 31/32 × 4 × 2 31/32 × 7/16	3.96	13.46	9.40	6.09	1 63	4.7	2.3
3 1/32 × 4 1/16 × 3 1/32 × 1/2	4.56	15.50	10.92	7.21	1.94	5.4	2.6
3 3/32 × 4 1/8 × 3 3/32 × 9/16	5.16	17.54	12.40	8.40	2.27	6.0	3.0
3 1/16 × 4 × 3 1/16 × 5/8	5.55	18.80	12 11	8.73	2.32	6.1	3.2
3 1/8 × 4 1/16 × 3 1/8 × 11/16	6.14	20.87	13.52	9.96	2.67	6.7	3.6
3 3/16 × 4 1/8 × 3 3/16 × 3/4	6.75	22.95	14.97	11 24	3.03	7.3	4.0
3 3/16 × 5 × 3 3/16 × 5/16	3.36	11.42	13.14	5.81	1.66	5.3	1.9
3 1/4 × 5 1/16 × 3 1/4 × 3/8	4.05	13.77	15.93	7.20	2.28	6.3	2.4
3 5/16 × 5 1/8 × 3 5/16 × 7/16	4.75	16.15	18.76	8.67	2.75	7.3	2.8
3 7/32 × 5 × 3 7/32 × 1/2	5.23	17 78	19 03	8.77	2.76	7.6	3.0
3 9/32 × 5 1/16 × 3 9/32 × 9/16	5.91	20.09	21.65	10.19	3.20	8.6	3.4
3 11/32 × 5 1/8 × 3 11/32 × 5/8	6.60	22.44	24.33	11.70	3.73	9.5	3.9
3 1/4 × 5 × 3 1/4 × 11/16	6.96	23.66	23.68	11.37	3.59	9.5	3.9
3 5/16 × 5 1/16 × 3 5/16 × 3/4	7.64	25.97	26.16	12.83	4.12	10.3	4.4
3 3/8 × 6 × 3 3/8 × 3/8	4.59	15 61	25.32	9.11	3.11	8.4	2.8
3 7/16 × 6 1/16 × 3 7/16 × 7/16	5.39	18.32	29.80	10.95	3.74	9.8	3.3
3 1/2 × 6 1/8 × 3 1/2 × 1/2	6.19	21.05	34.36	12.87	4.37	11 2	3.8
3 1/2 × 6 × 3 1/2 × 9/16	6.68	22.71	34.64	12 59	4.37	11.6	3.9
3 9/16 × 6 1/16 × 3 9/16 × 5/8	7.46	25.36	38.86	14.42	4.92	12 8	4 4
3 5/8 × 6 1/8 × 3 5/8 × 11/16	8.25	28.05	43.18	16·34	5.06	14.1	5.0
3 1/2 × 6 × 3 1/2 × 3/4	8.64	29 37	42.12	15.44	5.61	14.0	4.9
3 9/16 × 6 1/16 × 3 9/16 × 13/16	9.38	31.89	46.13	17.27	6 16	15.2	5.5
3 5/8 × 6 1/8 × 3 5/8 × 7/8	10.16	34.54	50 22	19.18	6.85	16.4	6.0

ELEMENTS OF Z BARS.

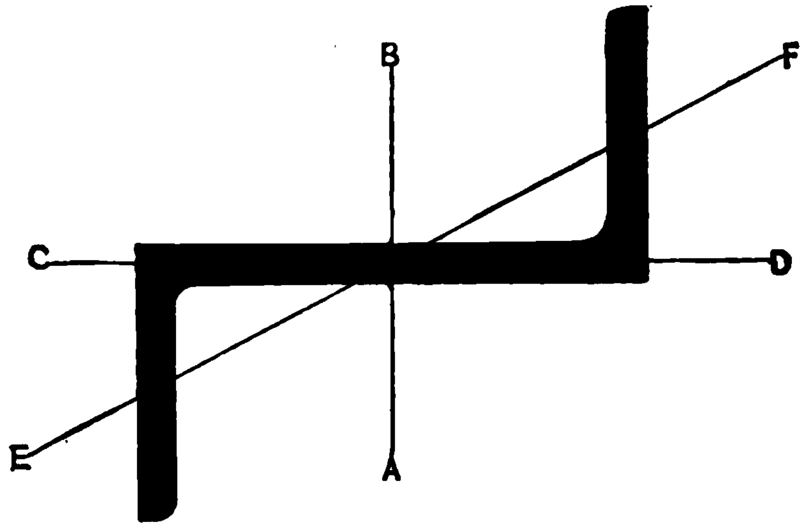


FIG. 110.

Radii of Gyration. Axis AB.	Axis CD.	Least Axis EF.	Coefficient in Net Tons for Greatest Safe Load Distance. Fibre Stress 16,000 Lbs.	Fibre Stress 12,000 Lbs.	Coefficient for Deflection about Axis AB. Distributed.	Centre.	Maximum Load in Net Tons.
1.20	1.16	0.55	10.0	7.5	.0005694	.0009167	11.0
1.20	1.18	0.55	12.3	9.2	.0004545	.0007317	14.4
1.21	1.20	0.56	14.8	11.1	.0003687	.0005937	18.0
1.13	1.14	0.54	14.9	11.2	.0003809	.0006132	20.4
1.14	1.15	0.54	16.0	12.0	.0003524	.0005674	22.2
1.14	1.16	0.55	17.0	12.8	.0003279	.0005279	24.0
1.60	1.22	0.64	15.9	11.9	.0002689	.0004329	13.6
1.61	1.24	0.65	19.7	14.8	.0002128	.0003426	18.2
1.62	1.26	0.66	23.6	17.7	.0001750	.0002817	23.0
1.54	1.24	0.64	25.1	18.8	.0001702	.0002740	26.6
1.55	1.27	0.65	28.7	21.5	.0001465	.0002359	31.2
1.55	1.28	0.66	32.1	24.1	.0001290	.0002077	35.8
1.48	1.26	0.65	32.3	24.2	.0001321	.0002127	39.0
1.48	1.27	0.66	35.5	26.6	.0001183	.0001905	43.6
1.49	1.29	0.67	38.7	29.0	.0001069	.0001721	48.6
1.98	1.32	0.74	28.0	21.0	.0001218	.0001961	21.4
1.98	1.33	0.75	33.6	25.2	.0001005	.0001618	27.0
1.99	1.35	0.76	39.1	29.3	.0000853	.0001373	32.8
1.91	1.30	0.73	40.6	30.5	.0000841	.0001354	37.6
1.91	1.31	0.74	45.6	34.2	.0000739	.0001190	43.2
1.92	1.33	0.75	50.6	38.0	.0000658	.0001059	49.0
1.84	1.28	0.72	50.5	37.9	.0000676	.0001088	53.2
1.85	1.30	0.73	55.1	41.3	.0000612	.0000984	59.0
2.35	1.41	0.82	45.0	33.8	.0000632	.0001017	30.8
2.35	1.43	0.83	52.4	39.3	.0000537	.0000864	37.6
2.36	1.44	0.84	59.8	44.9	.0000466	.0000750	44.6
2.28	1.37	0.81	61.6	46.2	.0000462	.0000744	50.2
2.28	1.39	0.81	68.4	51.3	.0000412	.0000663	57.0
2.29	1.41	0.83	75.2	56.4	.0000370	.0000596	64.0
2.21	1.34	0.81	74.9	56.2	.0000380	.0000612	69.0
2.22	1.36	0.81	81.2	60.9	.0000347	.0000559	76.0
2.22	1.37	0.82	87.5	65.6	.0000319	.0000513	83.0

BENDING MOMENTS OF PINS.

Moment $= \frac{\pi}{32} D^3 f.$ Diameter $= \sqrt[3]{\dfrac{\left(\frac{M}{f}\right)}{\frac{\pi}{32}}}.$

Diameter of Pin in Inches.	Area of Pin in Square Inches.	Moments in Inch-Pounds for Fibre Strains of			
		15,000 Lbs. per Sq. Inch.	20,000 Lbs. per Sq. Inch.	22,000 Lbs. per Sq. Inch.	25,000 Lbs. per Sq. Inch.
1	0.785	1,470	1,960	2,160	2,450
1⅛	0.994	2,100	2,800	3,080	3,500
1¼	1.227	2,880	3,830	4,220	4,790
1⅜	1.485	3,830	5,100	5,620	6,380
1½	1.767	4,970	6,630	7,290	8,280
1⅝	2.074	6,320	8,430	9,270	10,500
1¾	2.405	7,890	10,500	11,570	13,200
1⅞	2.761	9,710	12,900	14,240	16,200
2	3,142	11,800	15,700	17,280	19,600
2⅛	3.547	14,100	18,800	20,730	23,600
2¼	3.976	16,800	22,400	24,600	28,000
2⅜	4.430	19,700	26,300	28,900	32,900
2½	4.909	23,000	30,700	33,700	38,400
2⅝	5.412	26,600	35,500	39,000	44,400
2¾	5.940	30,600	40,800	44,900	51,000
2⅞	6.492	35,000	46,700	51,300	58,300
3	7.069	39,800	53,000	58,300	66,300
3⅛	7.670	44,900	59,900	65,900	74,900
3¼	8.296	50,600	67,400	74,100	84,300
3⅜	8.946	56,600	75,500	83,000	94,400
3½	9.621	63,100	84,200	92,600	105,200
3⅝	10.321	70,100	93,500	102,900	116,900
3¾	11.045	77,700	103,500	113,900	129,400
3⅞	11.793	85,700	114,200	125,600	142,800
4	12.566	94,200	125,700	138,200	157,100
4⅛	13.364	103,400	137,800	151,600	172,300
4¼	14.186	113,000	150,700	165,800	188,400
4⅜	15.033	123,300	164,400	180,800	205,500
4½	15.904	134,200	178,900	196,800	223,700
4⅝	16.800	145,700	194,300	213,700	242,800
4¾	17.721	157,800	210,400	231,500	263,000
4⅞	18.665	170,600	227,500	250,200	284,400
5	19.635	184,100	245,400	270,000	306,800
5⅛	20.629	198,200	264,300	290,700	330,400
5¼	21.648	213,100	284,100	312,500	355,200
5⅜	22.691	228,700	304,900	335,400	381,100
5½	23.758	245,000	326,700	359,300	408,300
5⅝	24.850	262,100	349,500	384,400	436,800
5¾	25.967	280,000	373,300	410,600	466,600
5⅞	27.109	298,600	398,200	438,000	497,700

BENDING MOMENTS OF PINS.—(*Continued.*)

$$\text{Moment} = \frac{\pi}{32} D^3 f. \qquad \text{Diameter} = \sqrt[3]{\frac{\left(\frac{M}{f}\right)}{\frac{\pi}{32}}}.$$

Diameter of Pin in Inches.	Area of Pin in Square Inches.	Moments in Inch-Pounds for Fibre Strains of			
		15,000 Lbs. per Sq. Inch.	20,000 Lbs. per Sq. Inch.	22,000 Lbs. per Sq. Inch.	25,000 Lbs. per Sq. Inch.
6	28.274	318,100	424,100	466,500	530,200
6⅛	29.465	338,400	451,200	496,300	564,000
6¼	30.680	359,500	479,400	527,300	599,200
6⅜	31.919	381,500	508,700	559,600	635,900
6½	33.183	404,400	539,200	593,100	674,000
6⅝	34.472	428,200	570,900	628,000	713,700
6¾	35.785	452,900	603,900	664,200	754,800
6⅞	37.122	478,500	638,000	701,800	797,500
7	38.485	505,100	673,500	740,800	841,900
7⅛	39.871	532,700	710,200	781,200	887,800
7¼	41.282	561,200	748,200	823,000	935,300
7⅜	42.718	590,700	787,600	866,300	984,500
7½	44.179	621,300	828,400	911,200	1,035,400
7⅝	45.664	652,900	870,500	957,500	1,088,100
7¾	47.173	685,500	914,000	1,005,300	1,142,500
7⅞	48.707	719,200	958,900	1,054,800	1,198,700
8	50.265	754,000	1,005,300	1,105,800	1,256,600
8⅛	51.849	789,900	1,053,200	1,158,500	1,316,500
8¼	53.456	826,900	1,102,500	1,212,800	1,378,200
8⅜	55.088	865,100	1,153,400	1,268,800	1,441,800
8½	56.745	904,400	1,205,800	1,326,400	1,507,300
8⅝	58.426	944,900	1,259,800	1,385,800	1,574,800
8¾	60.132	986,500	1,315,400	1,446,900	1,644,200
8⅞	61.862	1,029,400	1,372,500	1,509,800	1,715,700
9	63.617	1,073,500	1,431,400	1,574,500	1,789,200
9⅛	65.397	1,118,900	1,491,900	1,641,100	1,864,800
9¼	67.201	1,165,500	1,554,000	1,709,400	1,942,500
9⅜	69.029	1,213,400	1,617,900	1,779,600	2,022,300
9½	70.882	1,262,600	1,683,400	1,851,800	2,104,300
9⅝	72.760	1,313,100	1,750,800	1,925,900	2,188,500
9¾	74.662	1,364,900	1,819,900	2,001,900	2,274,900
9⅞	76.590	1,418,100	1,890,800	2,079,900	2,363,500
10	78.54	1,472,600	1,963,500	2,159,900	2,454,400
10¼	82.52	1,585,900	2,114,500	2,325,900	2,643,100
10½	86.59	1,704,700	2,273,000	2,500,200	2,841,200
10¾	90.76	1,829,400	2,439,300	2,683,200	3,049,100
11	95.03	1,960,100	2,613,400	2,874,800	3,266,800
11¼	99.40	2,096,800	2,795,700	3,075,400	3,494,800
11½	103.87	2,239,700	2,986,300	3,284,800	3,732,800
12	113.10	2,544,700	3,392,900	3,732,200	4,241,200

TEES AS STRUTS.

r = least radius of gyration.

Size of Tee in Inches.	Length in Feet.									
	2	4	6	8	10	12	14	16	18	20
	Greatest Safe Load in Pounds per Square Inch of Section									
4×4 $r = .85$	16,280	12,110	9,640	7,610	5,840	4,280	3,040	2,330	1,840	1,430
$3\frac{1}{2} \times 3\frac{1}{2}$ $r = .73$	14,680	11,200	8,600	6,420	4,550	3,060	2,250	1,710	1,250	...
3×3 $r = .62$	13,670	10,210	7,390	5,060	3,190	2,210	1,590	...	...	...
$2\frac{1}{2} \times 2\frac{1}{2}$ $r = 54$	13,010	9,310	6,310	3,860	2,400	1,660	...	...	...	...
$2\frac{1}{4} \times 2\frac{1}{4}$ $r = 48$	12,600	8,500	5,330	2,960	1,910	1,200	...	...	...	...
2×2 $r = 41$	11,870	7,330	3,970	2,170	1,290	...	...	...	...	...
$1\frac{3}{4} \times 1\frac{3}{4}$ $r = 36$	11,130	6,310	2,960	1,660	...	...	...	...	...	...
$1\frac{1}{2} \times 1\frac{1}{2}$ $r = 32$	10,400	5,330	2,340	1,200	...	...	...	...	...	...
$1\frac{1}{4} \times 1\frac{1}{4}$ $r = .30$	10,000	4,780	2,070	...	...	...	...	...	...	...
1×1 $r = .26$	9,060	3,540	1,510	...	...	...	...	...	...	...

SHACKLES.

For most purposes in ship details where shackles are used, it is common practice to order the shackles given in Table of trade shackles, suiting the size to the chain, wire or manila rope that

SPECIAL SHACKLES

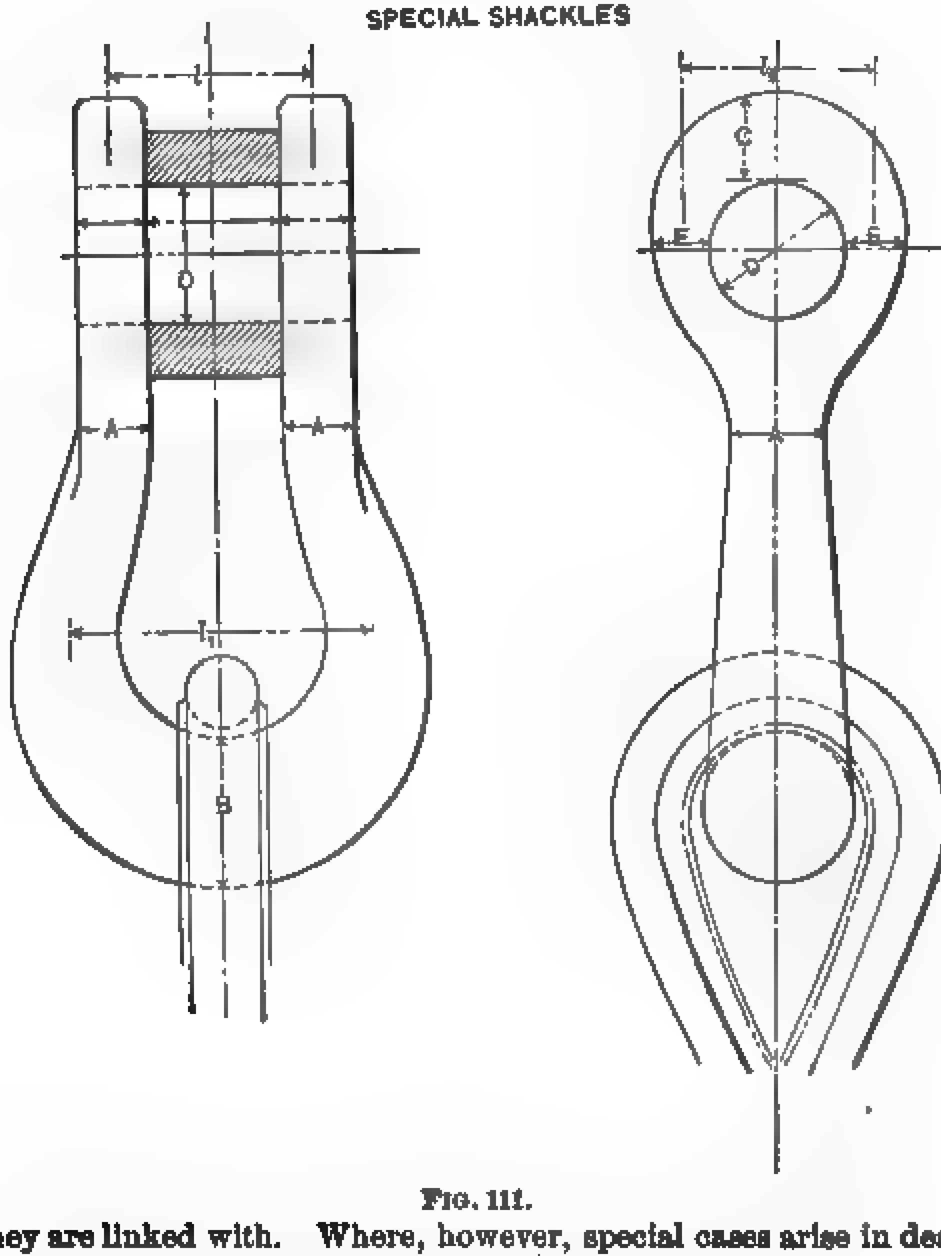


FIG. 111.

they are linked with. Where, however, special cases arise in dealing with exceptional loads the size of the shackle and pin should be accurately calculated, taking care that the widths between jaws and across the bow are no greater than necessary to take the con-

nections, as these dimensions are considered as the beams supporting the load as in the diagram.

The dimensions are required of a shackle to take a working load of 10 tons (22,400 lbs.), with a factor of safety of 6 equal to a unit stress of 10,000 lbs. It is assumed that the pin is shipped in a pad-eye, bearing along its entire length, *i.e.*, the load is distributed. We thus have the case of a beam supported at the ends and uniformly loaded, the maximum bending moment M being $\frac{Wl}{8}$. The length l (3″) will have previously been determined by the bearing value given in designing the pad-eye. Then,

$$\frac{Wl}{8} = \frac{22{,}400 \times 3}{8} = 8{,}400 \text{ inch-pounds} = M.$$

The moment of resistance of a circular section (the pin) is equal to $\frac{\pi}{32} D^3$, therefore the diameter D which will equal this bending moment (M) just figured with a fibre stress of 10,000 lbs. must be,

$$D = \sqrt[3]{\frac{M}{\frac{\pi}{32} \times f}} = \sqrt[3]{\frac{8{,}400}{.0982 \times 10{,}000}} = 2.04 \text{ inches.}$$

The diameter of the wire forming the bow at B is calculated in a similar way, noting that the load this time is central, but the ends of the beam being now fixed, we have the same formula for the maximum bending moment, viz., $\frac{Wl_1}{8}$. Assuming that it has been necessary to bow the shackle, "l_1" has now been increased to 4 inches, so that

$$\frac{Wl_1}{8} = \frac{22{,}400 \times 4}{8} = 11{,}200 \text{ inch-pounds} = M,$$

and applying the formula for a circular section as in the pin, we have

$$\sqrt[3]{\frac{11{,}200}{.0982 \times 10{,}000}} = 2\tfrac{1}{4} \text{ inches diameter at } B.$$

From the diameter B the wire may be tapered to A, where the sectional area need only be such as will resist tension, but it is usual in practice to increase this amount by 25%, owing to the load at times becoming eccentric, thus throwing a greater stress on one leg.

$$\frac{W}{f} = \frac{22{,}400 \text{ lbs.}}{10{,}000 \text{ lbs.}} = 2.24 \text{ sq. in.} + 25\% = 2.8 \text{ sq. in.}$$

$$= 1.4 \text{ sq. in. per leg.}$$

$$= 1\tfrac{3}{8} \text{ in. diameter at } A.$$

The sectional area and dimension C are computed by considering l_2 the length of beam which is now fixed at both ends and uniformly loaded when M is equal to $\frac{W l_2}{12}$. The dimensions are calculated as in the foregoing, observing that the resistance is now for a rectangle, and the bending moment will consequently equal

$$\frac{A C^2}{6} \times f.$$

CHAPTER IV.

STANDARD RIVETING, U. S. NAVY.

1. All rivet holes through material 1 inch or more in thickness should be drilled, or if punched should afterwards be reamed to finished size.

2. In cases where rivets connect plates of different thickness the size of rivet indicated for the greater thickness with corresponding spacing will be used where strength is required, and that indicated for the lesser thickness where water tightness is a special consideration, always provided the greater thickness is not more than double the lesser.

3. Where tap-rivets must be used they should be $\frac{1}{8}$ inch larger than the corresponding ordinary rivets for the same thickness, except taps into heavy castings and forgings such as stem and stern posts, which should be $\frac{1}{4}$ inch larger. Where strength is required, taps should not penetrate less than one diameter, and should penetrate $1\frac{1}{2}$ diameters when the thickness of metal will allow it.

4. Where the spacing given in Table No. 3 cannot be followed exactly, as will generally be the case, make the spacing a trifle closer (as necessary with heavier plating) and a trifle further apart (as necessary with lighter plating), the division between "*heavier*" and "*lighter*" plating coming at $7\frac{1}{2}$-pound plates for single riveting; at 15-pound plates for double riveting and at 25-pound plates for treble riveting.

5. Where the above distinctions are considered too complicated for yard work, the general rule will be to space a trifle closer in all cases, as necessary for equal spacing.

6. Where strength is required in laps and butted connections of plating, with the spacing indicated, single riveting is suitable only for plating under $12\frac{1}{2}$ pounds, and double riveting for plating under 25 pounds. For maximum strength in connections of plating above 30 pounds it will generally be found that quadruple riveting is required.

Single Straps.

7. Single butt straps and edge strips, when single or double riveted, should be the same thickness as the plates connected, and where the plates connected are of different thickness, the straps or strips should be of the same thickness as the lighter plate. Single butt straps when treble riveted should be $1\frac{1}{4}$ times the thickness of *the plates* they connect.

Double Butt Straps.

8. Double butt straps should not be used for water-tight work, owing to the difficulty in caulking. They may be used to advantage in conditions requiring great strength but not water-tightness. The thickness of each strap should be ½ the thickness of plates connected for double riveted straps, and ⅝ the thickness for treble riveted straps. The spacing of rivets in rows should be calculated. Size of rivets for double butt straps as follows:

For plates from 15 to 20 pounds, exclusive, ⅝ inch rivets.
" " " 20 to 25 " inclusive, ¾ " "
" " above 25 pounds, see Table No. 1.

Distance between Rows.

9. Centres of rivets should be placed not less than 1⅝ times the diameter from the edges of plates connected. In double and treble riveting for laps and single straps, the distance from centre to centre of rows should not be less than 2½ diameters; in butt laps and double butt straps the distance between centres of rows should be not less than 3 diameters. (Butt laps should be at least double riveted.) For zigzag riveting the distance between centres of rows should not be less than 1¾ diameters for rivets spaced 4 diameters apart in rows.

TABLE I.—Diameter of Rivets.

Weight of Plates.	Diameters of Corresponding Rivet.	Diameters of Rivet Holes.
For Torpedo Boat Work.	In.	In.
Up to 3 pounds, inclusive	$\frac{1}{4}$	$\frac{9}{32}$
3 pounds to 6 pounds, exclusive	$\frac{5}{16}$	$\frac{11}{32}$
6 pounds to $7\frac{1}{2}$ pounds, exclusive	$\frac{3}{8}$	$\frac{7}{16}$
$7\frac{1}{2}$ pounds to 9 pounds, exclusive	$\frac{7}{16}$	$\frac{1}{2}$
9 pounds to 11 pounds, exclusive	$\frac{1}{2}$	$\frac{9}{16}$
11 pounds to 13 pounds, exclusive	$\frac{5}{8}$	$\frac{11}{16}$
For Ship Work.		
Up to 3 pounds, exclusive	$\frac{1}{4}$	$\frac{9}{32}$
3 pounds to 6 pounds, exclusive	$\frac{3}{8}$	$\frac{7}{16}$
6 pounds, inclusive, to 8 pounds, exclusive,	$\frac{1}{2}$	$\frac{9}{16}$
8 pounds, inclusive, to 13 pounds, exclusive,	$\frac{5}{8}$	$\frac{11}{16}$
13 pounds, inclusive, to 20 pounds, exclusive,	$\frac{3}{4}$	$\frac{13}{16}$
20 pounds, inclusive, to 30 pounds, exclusive,	$\frac{7}{8}$	$\frac{15}{16}$
30 pounds, inclusive, to 40 pounds, exclusive,	1	$1\frac{1}{16}$
40 pounds, inclusive, to 51 pounds, exclusive,	$1\frac{1}{8}$	$1\frac{7}{32}$
51 pounds and above	$1\frac{1}{4}$	$1\frac{11}{32}$

TABLE II. — Breadth of Laps and Straps.

Item.	Diameters.
Breadth of laps for single riveting	3¼
" " " " double chain riveting	5¾
" " " " " zigzag riveting	5
" " double riveted butt laps	6¼
" " laps for treble riveting	8¼
" " treble riveted butt laps in outside plating	9¼
" " edge strip for single riveting	6½
" " edge strip for double riveting	11½
" " butt strap for double riveting	11½
" " butt strap for treble riveting	16½
" " double butt strap, double riveted . . .	12½
" " double butt strap, treble riveted	18½

TABLE III. — Spacing of Rivets.

	Pitch in Diameters.
Single riveted butt laps and butt straps	$3\frac{1}{2}$
Double riveted butt laps and butt straps	4
Treble riveted butt laps	$4\frac{1}{2}$
Treble riveted butt straps with alternate rivets in third row omitted	4
All longitudinal seams of plating required to be water-tight	$4\frac{1}{2}$
Connections of transverse frames not water-tight to outside plating	8
Connections of deck plating to beams, of non-water-tight longitudinals to outside plating, of the angles and stiffeners to bulkheads when entirely above the water line, and in general where special strength is not required	8
Connections of floor plates, brackets, lightened intercostals, etc., to clips and angles, of the vertical keel angles to the flat and vertical keel plates and to the flat keelson plates beyond the limits of double bottom, provided water-tightness is not required	7
Connections of angles and other stiffeners to bulkheads at or below the water line, of boiler and engine bearings and foundations in general	6
Connections of inner bottom plating to all frames and longitudinals	5
Connections of angles of water-tight frames and longitudinals to all plating, and in general where water-tightness is required between shapes and plates .	5
Angles and other stiffeners to bulkheads forming supports to turrets, barbettes, connections of armor shelf angles to plating, etc.	5
Connections between staple angles of water-tight floors and the floor plates	$4\frac{1}{2}$
In special cases of intercostals, beam ends, etc., where strength is required in connections of limited strength and in all other exceptional cases, spacing to be as required by circumstances, except that the rivets in the same line should never be less than	3

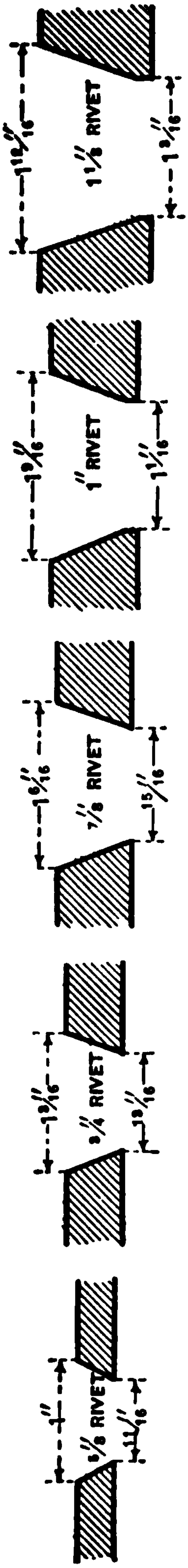
TABLE IV. — Reduction of Diameters to Inches.

Diameter of Rivet.	Number of Diameters.																			
	1⅝	2½	3	3¼	3½	4	4½	5	5¾	6	6¼	6½	7	8	8¼	9¼	11½	12½	16½	18½
¼ in.	⅜	⅝	¾	13/16	⅞	1	1 ⅛	1 ¼	1 7/16	1 ½	1 9/16	1 ⅝	1 ¾	2	2 1/16	2 5/16	2 ⅞	3 ⅛	4 ⅛	4 ⅝
5/16 "	½	¾	15/16	1	1 1/16	1 ¼	1 ⅜	1 9/16	1 13/16	1 ⅞	1 15/16	2	2 3/16	2½	2 9/16	2 ⅞	3 9/16	3 ⅞	5 ⅛	5 ¾
⅜ "	⅝	15/16	1 ⅛	1 3/16	1 5/16	1 ½	1 11/16	1 ⅞	2 ⅛	2 ¼	2 5/16	2 7/16	2 ⅝	3	3 1/16	3 7/16	4 5/16	4 11/16	6 3/16	6 15/16
7/16 "	11/16	1 1/16	1 5/16	1 7/16	1 ½	1 ¾	2	2 3/16	2 ½	2 ⅝	2 ¾	2 ⅞	3 1/16	3½	3 ⅝	4 1/16	5	5 7/16	7 3/16	8 1/16
½ "	13/16	1 ¼	1 ½	1 ⅝	1 ¾	2	2 ¼	2 ½	2 ⅞	3	3 ⅛	3 ¼	3 ½	4	4 ⅛	4 ⅝	5 ¾	6 ¼	8 ¼	9 ¼
⅝ "	1	1 9/16	1 ⅞	2	2 3/16	2 ½	2 13/16	3 ⅛	3 ⅝	3 ¾	3 15/16	4 1/16	4 ⅜	5	5 3/16	5 13/16	7 3/16	7 13/16	10 5/16	11 9/16
¾ "	1 3/16	1 ⅞	2 ¼	2 7/16	2 ⅝	3	3 ⅜	3 ¾	4 5/16	4 ½	4 ¾	4 ⅞	5 ¼	6	6 3/16	6 15/16	8 ⅝	9 ⅜	12 ⅜	13 ⅞
⅞ "	1 7/16	2 3/16	2 ⅝	2 13/16	3 1/16	3 ½	3 15/16	4 ⅜	5	5 ¼	5 ½	5 ¾	6 ⅛	7	7 3/16	8 1/16	10 1/16	10 15/16	14 7/16	16 3/16
1 "	1 ⅝	2 ½	3	3 ¼	3 ½	4	4 ½	5	5 ¾	6	6 ¼	6 ½	7	8	8 ¼	9 ¼	11 ½	12 ½	16 ½	18 ½
1⅛ "	1 13/16	2 13/16	3 ⅜	3 ⅝	3 15/16	4 ½	5 1/16	5 ⅝	6 7/16	6 ¾	7	7 5/16	7 ⅞	9	9 ¼	10 ⅜	12 15/16	14 1/16	18 9/16	20 13/16
1¼ "	2	3 ⅛	3 ¾	4 1/16	4 ⅜	5	5 ⅝	6 ¼	7 3/16	7 ½	7 13/16	8 ⅛	8 ¾	10	10 5/16	11 9/16	14 ⅜	15 ⅝	20 ⅝	23 ⅛

TABLE V. — Combination Table for Ship Work.

Gauge of Plates.	Corresponding Thickness.	Diameter of Rivet.	Diameter of Hole.	Breadth of Laps.						Widths of Strips & Single Straps.		
				Single Riveting.	Double Chain Riveting.	Double Zigzag Riveting.	Treble Chain Riveting.	Double Riveted Butt Laps.	Treble Riveted Butt Laps.	Single Riveting.	Double Riveting.	Treble Riveting.
Pounds per Sq. Foot.	Thirty-Seconds of an Inch.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
Up to 3 Ex.	Up to 2	$\frac{1}{4}$	$\frac{9}{32}$	$\frac{13}{16}$	$1\frac{7}{16}$	$1\frac{1}{4}$	$2\frac{1}{16}$	$1\frac{9}{16}$	$2\frac{5}{16}$	$1\frac{5}{8}$	$2\frac{7}{8}$	$4\frac{1}{8}$
3–6 "	2–5	$\frac{3}{8}$	$\frac{7}{16}$	$1\frac{3}{16}$	$2\frac{1}{8}$	$1\frac{7}{8}$	$3\frac{1}{16}$	$2\frac{5}{16}$	$3\frac{7}{16}$	$2\frac{7}{16}$	$4\frac{5}{16}$	$6\frac{5}{16}$
6–8 "	5–7	$\frac{1}{2}$	$\frac{9}{16}$	$1\frac{5}{8}$	$2\frac{7}{8}$	$2\frac{1}{2}$	$4\frac{1}{8}$	$3\frac{1}{8}$	$4\frac{5}{8}$	$3\frac{1}{4}$	$5\frac{3}{4}$	$8\frac{1}{4}$
8–13 "	7–11	$\frac{5}{8}$	$\frac{11}{16}$	$2\frac{3}{16}$	$3\frac{5}{8}$	$3\frac{1}{8}$	$5\frac{3}{16}$	$3\frac{15}{16}$	$5\frac{15}{16}$	$4\frac{1}{16}$	$7\frac{3}{16}$	$10\frac{5}{16}$
13–20 "	11–16	$\frac{3}{4}$	$\frac{13}{16}$	$2\frac{7}{16}$	$4\frac{5}{16}$	$3\frac{3}{4}$	$6\frac{1}{16}$	$4\frac{3}{4}$	$6\frac{15}{16}$	$4\frac{7}{8}$	$8\frac{5}{8}$	$12\frac{3}{8}$
20–30 "	15–24	$\frac{7}{8}$	$\frac{15}{16}$	. .	5	$4\frac{3}{8}$	$7\frac{3}{16}$	$5\frac{1}{2}$	$8\frac{1}{16}$	$5\frac{3}{4}$	$10\frac{1}{16}$	$14\frac{7}{16}$
30–40 "	24–32	1	$1\frac{1}{16}$	. .	$5\frac{3}{4}$	5	$8\frac{1}{4}$	$6\frac{1}{4}$	$9\frac{1}{4}$	$6\frac{1}{2}$	$11\frac{1}{2}$	$16\frac{1}{2}$
40–51 "	32–41	$1\frac{1}{8}$	$1\frac{7}{32}$	. .	. .	. .	$9\frac{1}{4}$	7	$10\frac{3}{8}$	$7\frac{5}{16}$	$12\frac{15}{16}$	$18\frac{9}{16}$
51 & over	41 & over	$1\frac{1}{4}$	$1\frac{11}{32}$	. .	. .	. .	$10\frac{5}{16}$	$7\frac{13}{16}$	$11\frac{9}{16}$	$8\frac{1}{8}$	$14\frac{3}{8}$	$20\frac{5}{8}$

LLOYD'S COUNTERSINKS.

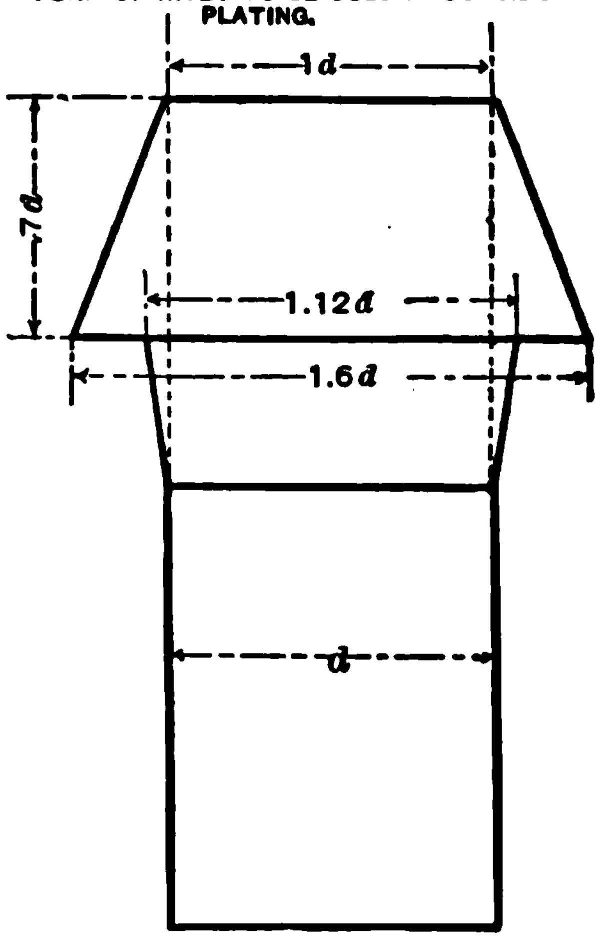


SIZE OF COUNTERSINK OF RIVETS IN OUTSIDE PLATING.

THE COUNTERSINK IS TO EXTEND THROUGH THE WHOLE THICKNESS OF THE PLATE WHEN LESS THAN 14/20 INCH IN THICKNESS; WHEN 14/20 INCH OR ABOVE, THE COUNTERSINK IS TO EXTEND THROUGH NINE-TENTHS THE THICKNESS OF THE PLATE.

FIGS. 112–116.

FORM OF RIVET TO BE USED IN OUTSIDE PLATING.



THE TAPERED NECK OF RIVET TO BE OF SUITABLE LENGTH IN RELATION TO THE THICKNESS OF PLATE IN WHICH IT IS INTENDED TO BE USED.

FIG. 117.

LLOYD'S RIVETING

Showing Diameters and Spacing of Rivets and

		"	"	"
Thickness of plates		$\frac{5}{20}$	$\frac{6}{20}$	$\frac{6}{20}$ & $\frac{7}{20}$
Diameter of rivets		$\frac{5}{8}$	$\frac{5}{8}$	$\frac{3}{4}$
Breadth of treble riveted straps in inches		..	..	...
" " double riveted straps in inches		8	8	$9\frac{3}{4}$
" " quadruple riveted butt laps in inches		..	..	...
" " treble riveted butt laps in inches		..	..	...
" " double riveted butt laps in inches		$4\frac{1}{4}$	$4\frac{1}{4}$	5
" " treble riveted edge laps in inches		..	..	...
" " double riveted edge laps in inches		$3\frac{3}{4}$	$3\frac{3}{4}$	$4\frac{1}{2}$
" " single riveted edge laps in inches		$2\frac{1}{4}$	$2\frac{1}{4}$	$2\frac{1}{2}$
Maximum Spacing C. to C. — $3\frac{1}{2}$ dia. c. to c.	In † butts of outside plating, and of upper, spar and middle deck stringers and the stringers of bridge decks which exceed one-third the length of the vessel amidships (except quadruple riveted butt laps).	$2\frac{1}{4}$	$2\frac{1}{4}$	$2\frac{5}{8}$
4 dia. c. to c.	In quadruple riveted butt laps; butts of deck plating, margin plates, girders, lower deck and hold stringers, tie plates, floor plates, and stringer plates on other deck erections; also butts and edges of inner bottom plating.	$2\frac{1}{2}$	$2\frac{1}{2}$	3
$4\frac{1}{2}$ dia. c. to c.	In * edges of outside plating (forward and aft), gunwale angle bars, margin plate angles, edges and butts of bulkhead plating.	$2\frac{3}{4}$	$2\frac{3}{4}$	$3\frac{3}{8}$
5 dia. c. to c.	In flat keel angles, bulkhead frames where caulked, butts and edges of mast plates, and deck plating to beams where single flange beams are fitted to alternate frames.	$3\frac{1}{8}$	$3\frac{1}{8}$	$3\frac{3}{4}$
7 dia. c. to c.	In * frames, reversed frames, floors, keelsons, beam angles, deck and hold stringer angles, face angles on web frames and side stringers, bulkhead stiffeners, longitudinal angles on continuous girders, vertical angles connecting floors and girders and deck plating to beams except where single flange beams are fitted to alternate frames.	$4\frac{1}{2}$	$4\frac{1}{2}$	$5\frac{1}{4}$

† In butts connected by single butt straps alternate rivets may be omitted in the back row of treble riveting when the plating number is 20,000 and under; when above this number, the rivets in the back row are not to be more than 5 to $5\frac{1}{4}$ diameters apart from centre to centre. All overlapped butts are to have complete rows of rivets.

* When the rule frame spacing is 26 inches or above, the rivets in the edges of outside plating (forward and aft) are not to exceed 4 diameters apart from centre to centre, and the rivets attaching the outside plating to frames are to be spaced not more than 6 diameters apart from centre to centre.

In deep water ballast tanks above the level of inner bottom, and in fore and after peak water ballast tanks, the rivets through frames and outside plating are to be spaced not more than 6 diameters apart from centre to centre.

Before the three-fifths length of a steamer having a tonnage coefficient of .78, or having a full form at the fore part, the rivets in the landing edges of the strakes of plating forming the flat of the bottom to be spaced not more than 4 diameters apart from centre to centre. The rivets in the plating and frames in way of the same to be spaced not more than $5\frac{1}{2}$ diameters apart from centre to centre.

Rivets to be $\frac{1}{8}$ of an inch larger in diameter in the stem, stern frame, and keel, but in no case need these exceed $1\frac{1}{4}''$ in diameter, and to be spaced 5 diameters apart from centre to centre. In single screw steamers above 350 feet in length, the after lengths of shell plating are to be connected to the portion of the stern frame below the boss with 3 rows of rivets.

Rivets in side plate rudders to be of not less size than those required for the upper edge of garboard strake amidships, and to be spaced not more than

TABLE, 1903.

Breadths of Straps, Butt Laps, and Edge Laps.

″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″
$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{13}{20}$ & $\frac{14}{20}$	$\frac{15}{20}$	$\frac{16}{20}$	$\frac{17}{20}$	$\frac{18}{20}$	$\frac{19}{20}$ & $\frac{20}{20}$	$\frac{21}{20}$	$\frac{22}{20}$	$\frac{23}{20}$	$\frac{24}{20}$	$\frac{25}{20}$ & $\frac{26}{20}$	$\frac{27}{20}$	$\frac{28}{20}$	$\frac{29}{20}$
$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$	1	1	1	1	1	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$
. .	$14\frac{1}{2}$	$14\frac{1}{2}$	$14\frac{1}{2}$	$16\frac{3}{4}$	$16\frac{3}{4}$	$16\frac{3}{4}$	$16\frac{3}{4}$	19	19	19	19	19	$21\frac{1}{2}$	$21\frac{1}{2}$	$21\frac{1}{2}$	$21\frac{1}{2}$
$9\frac{3}{4}$	$9\frac{3}{4}$	$9\frac{3}{4}$	$9\frac{3}{4}$	$11\frac{1}{4}$	$11\frac{1}{4}$	$11\frac{1}{4}$	$11\frac{1}{4}$	. .	. .	. .	. .	. .	. . .	. .	. . .	.
. .	. .	. .	. . .	12	12	12	12	14	14	14	14	14	16	16	16	16
. .	$7\frac{1}{2}$	$7\frac{1}{2}$	$7\frac{1}{2}$	9	9	9	9	$10\frac{1}{2}$	$10\frac{1}{2}$	$10\frac{1}{2}$	$10\frac{1}{2}$	$10\frac{1}{2}$	12	12	12	12
5	5	5	5	6	6	6	6	. . .	. .	. .	. .	. .	. . .	. .	. .	. .
. .	. .	.	. . .	. .	. .	.	$7\frac{1}{2}$	$8\frac{1}{4}$	$8\frac{1}{4}$	$8\frac{1}{4}$	$8\frac{1}{4}$	$8\frac{1}{4}$	$9\frac{1}{4}$	$9\frac{1}{4}$	$9\frac{1}{4}$	$9\frac{1}{4}$
$4\frac{1}{4}$	$4\frac{1}{4}$	$4\frac{1}{4}$	$4\frac{1}{4}$	$5\frac{1}{4}$	$5\frac{1}{4}$	$5\frac{1}{4}$	$5\frac{1}{4}$	6	6	6	6	6	$6\frac{3}{4}$	$6\frac{3}{4}$	$6\frac{3}{4}$	$6\frac{3}{4}$
$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	3	3	3	3	. . .	. .	.	. .	. .	. . .	. .	. .	. .
$2\frac{5}{8}$	$2\frac{5}{8}$	$2\frac{5}{8}$	$2\frac{5}{8}$	$3\frac{1}{8}$	$3\frac{1}{8}$	$3\frac{1}{8}$	$3\frac{1}{8}$	$3\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{2}$	4	4	4	4
3	3	3	3	$3\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{2}$	4	4	4	4	4	$4\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{2}$
$3\frac{5}{8}$	$3\frac{5}{8}$	$3\frac{5}{8}$	$3\frac{5}{8}$	4	4	4	4	$4\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{2}$	. . .	. .	. .	. .
$3\frac{3}{4}$	$3\frac{3}{4}$	$3\frac{3}{4}$	$3\frac{3}{4}$	$4\frac{3}{8}$	$4\frac{3}{8}$	$4\frac{3}{8}$	$4\frac{3}{8}$	5	5	5	5	5	$5\frac{5}{8}$	$5\frac{5}{8}$	$5\frac{5}{8}$	$5\frac{5}{8}$
$5\frac{1}{4}$	$5\frac{1}{4}$	$5\frac{1}{4}$	$5\frac{1}{4}$	$6\frac{1}{4}$	$6\frac{1}{4}$	$6\frac{1}{4}$	$6\frac{1}{4}$	7	7	7	7	7	. . .	. .	. .	. .

5 diameters from centre to centre. The rudder plates are to be countersunk and the rivets are to have full heads and points.

Rivets in single plate rudders are to be of not less size than required for attaching the outside plating to the stern frame, and spaced not more than 5 diameters apart from centre to centre. The rivet holes are to be countersunk both in rudder plates and the arms, and the rivets are to have full heads and points.

Rivets in the edges of deck plating are to be spaced not more than 4 to $4\frac{1}{2}$ diameters apart from centre to centre.

In single riveted seams one frame rivet is to be fitted through the landing edges at each frame. In double riveted seams one frame rivet is to be fitted through the landing edges at each frame, except where the frames or the edges of the outside plating are joggled when two rivets are to be fitted. In treble riveted seams two frame rivets (the upper and lower) are to be fitted through the landing edges at each frame.

Where the fore and aft flange of the frame does not exceed 3 inches, the rivets attaching the outside plating thereto should not exceed $\frac{7}{8}$ inch in diameter, and where it is $3\frac{1}{2}$ inches wide, they should not exceed 1 inch in diameter.

There are to be at least four rivets in each flange of the angle bars between the frames which connect the stringer plates and intercostal plates to the outside plating. Where the frames are spaced less than 29 inches apart, and where the spacing is 29 inches and not more than 32 inches there are to be five rivets in each flange.

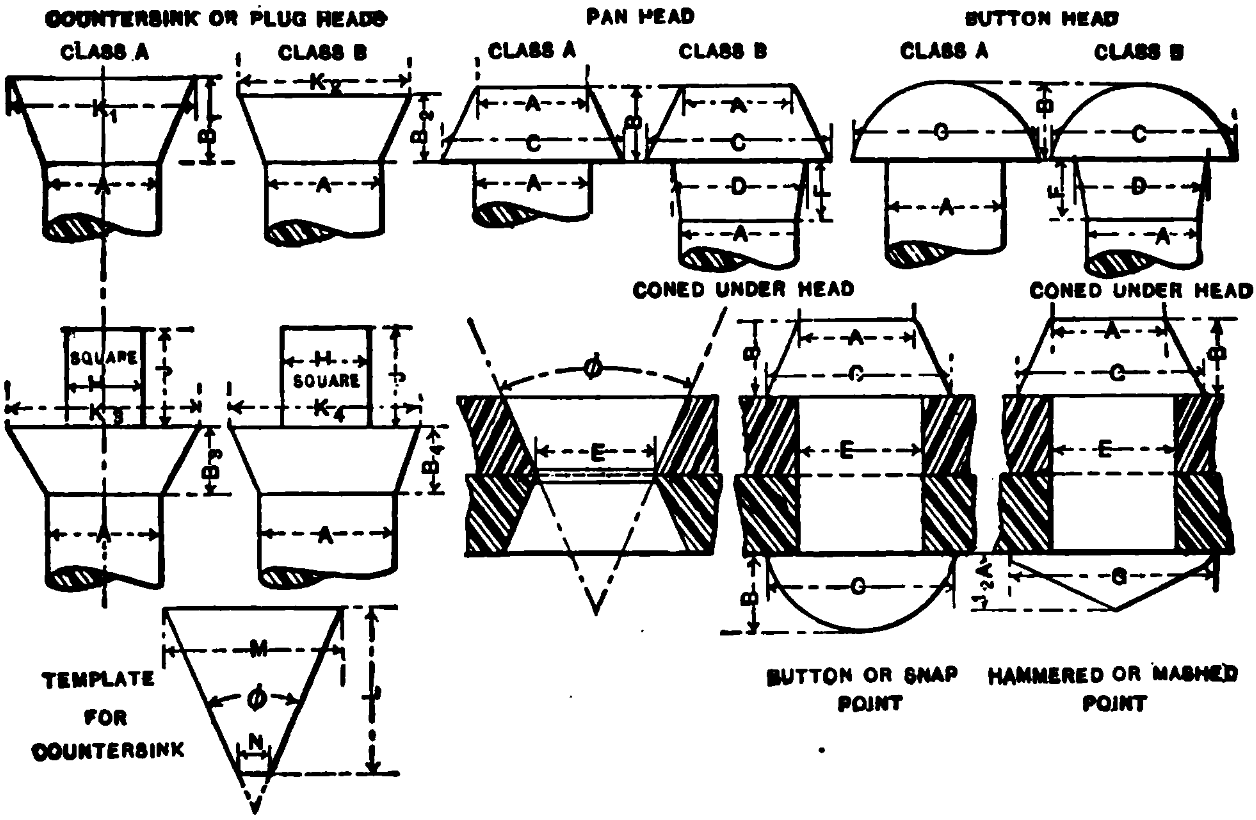
The rivets in the beam knees are to be in number and size as required.

The rivets in the vertical angles connecting floors and outside brackets to margin plates are to be in number and size as required.

The rivets in the connecting straps for web frames and side stringers are to be in number and size as required.

STANDARD RIVETS.

(See Table Opposite.)



Figs. 118–129.

STANDARD RIVETS.

Order Number.		Size of Rivet.	Diameter of Holes.	All Rivets.	Pan & Button Heads Snap Points.		Cone under Head.		Hammered Points.	Countersunk Heads. Class A.		Countersunk Heads. Class B.		Tap Rivets. Class A.		Tap Rivets. Class B.		Tap Rivets.		For Special Rivets Larger than 1¼" the Angle of Countersink should be = 32°.			
			$E.$	$A.$	$B.$	$C.$	$D.$	F	$G.$	$B_1.$	K_1	$B_2.$	K_2	B_3	$K_3.$	$B_4.$	$K_4.$	$H.$	J	$\phi.$	$L.$	$M.$	$N.$
		"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	Sq."	"	°	"	"	"
Torpedo Boats	I.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	..	..	[illegible]	[illegible]	..	..	..	..	..	..	..	..	..	60	2[illegible]	3[illegible]	[illegible]
	II.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	..	..	[illegible]	[illegible]	..	..	..	..	..	..	..	..	..	60	"	"	"
	III.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	..	..	[illegible]	[illegible]	..	..	..	..	..	..	..	..	..	60	"	"	"
	IV.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	..	..	[illegible]	[illegible]	..	..	..	..	..	..	..	..	..	60	"	"	"
	V.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	..	..	..	..	..	..	..	..	..	60	"	"	"
	VI.	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	1[illegible]	[illegible]	..	..	..	..	..	..	..	..	..	60	"	"	"
Ship Work	VII	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	..	..	[illegible]	[illegible]	[illegible]	..	..	..	..	..	..	..	..	53	2[illegible]	2[illegible]	[illegible]
	VIII.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	..	..	[illegible]	[illegible]	[illegible]	..	..	..	..	..	..	..	..	53	"	"	"
	IX.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	..	..	..	..	..	..	..	..	53	"	"	"
	X.	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	1[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	..	..	[illegible]	[illegible]	53	"	"	"
	XI.	[illegible]	[illegible]	[illegible]	[illegible]	1[illegible]	[illegible]	[illegible]	1[illegible]	[illegible]	1[illegible]	[illegible]	1[illegible]	[illegible]	[illegible]	..	..	[illegible]	[illegible]	45	3	2[illegible]	[illegible]
	XII	[illegible]	[illegible]	[illegible]	[illegible]	1[illegible]	[illegible]	[illegible]	1[illegible]	[illegible]	1[illegible]	[illegible]	1[illegible]	[illegible]	1[illegible]	[illegible]	1[illegible]	[illegible]	[illegible]	45	"	"	"
	XIII.	1	1[illegible]	1	[illegible]	1[illegible]	1[illegible]	[illegible]	1[illegible]	1	1[illegible]	[illegible]	1[illegible]	[illegible]	1[illegible]	[illegible]	1[illegible]	[illegible]	[illegible]	37	"	2[illegible]	[illegible]
	XIV.	1[illegible]	1[illegible]	1[illegible]	[illegible]	1[illegible]	1[illegible]	[illegible]	1[illegible]	..	..	[illegible]	1[illegible]	[illegible]	1[illegible]	..	..	[illegible]	[illegible]	37	"	"	"
	XV.	1[illegible]	1[illegible]	1[illegible]	[illegible]	1[illegible]	1[illegible]	[illegible]	2[illegible]	..	..	[illegible]	1[illegible]	[illegible]	1[illegible]	..	..	[illegible]	[illegible]	37	"	"	"
																				32	"	2[illegible]	"

MINIMUM NUMBER OF RIVETS IN EDGES OF PLATING BETWEEN FRAMES AMIDSHIPS, EXCLUDING RIVETS IN FRAMES. (LLOYD'S.)

Thickness of Plates.	Number of Rivets in Each Row.																			
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
	$\frac{6}{20}$	$\frac{7}{20}$	$\frac{8}{20}$ & $\frac{9}{20}$	$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{13}{20}$ & $\frac{14}{20}$	$\frac{15}{20}$	$\frac{16}{20}$	$\frac{17}{20}$	$\frac{18}{20}$	$\frac{19}{20}$ & $\frac{20}{20}$	$\frac{21}{20}$	$\frac{22}{20}$	$\frac{23}{20}$	$\frac{24}{20}$	$\frac{25}{20}$ & $\frac{26}{20}$	$\frac{27}{20}$	$\frac{28}{20}$	$\frac{29}{20}$
Diameter of Rivets.	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$	1	1	1	1	1	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{1}{4}$
Spacing of frames . 20″	7	7	5	5	5	5	..	..	..	..	..	..	..	..	..	..	..	..	..	..
" " " . 21″	..	7	6	6	6	6	6	5	5	..	..	..	..	..	..	..	..	..	..	..
" " " . 22″	..	..	6	6	6	6	6	5	5	5	5	..	..	..	..	..	..	..	..	..
" " " . 23″	..	..	6	6	6	6	6	5	5	5	5	5	5	5	5	..	..	..	..	..
" " " . 24″	..	..	7	7	7	7	7	6	6	6	6	5	5	5	5	5	..	..	..	..
" " " . 25″	..	..	..	..	..	..	..	6	6	6	6	5	5	5	5	5	..	..	..	..
" " " . 26″	..	..	..	..	..	..	..	..	..	7	7	6	6	6	6	6	5	5	5	5
" " " . 27″	..	..	..	..	..	..	..	..	..	7	7	6	6	6	6	6	5	5	5	5
" " " . 28″	..	..	..	..	..	..	..	..	..	7	7	6	6	6	6	6	6	6	6	6
" " " . 29″	..	..	..	..	..	..	..	..	..	8	8	7	7	7	7	7	6	6	6	6
" " " . 30″	..	..	..	..	..	..	..	..	..	8	8	7	7	7	7	7	6	6	6	6
" " " . 31″	..	..	..	..	..	..	..	..	..	..	..	7	7	7	7	7	6	6	6	6
" " " . 32″	..	..	..	..	..	..	..	..	..	..	..	8	8	8	8	8	7	7	7	7

RIVETING TABLE

Table of Straps and Rivets for Light Steel Work and Torpedo Boat Practice.

Thickness of Plate.	To $\frac{11}{G}$ or To $\frac{1}{8}''$	$\frac{10, 9, 8, 7}{\text{Gauge}}$ or over $\frac{1}{8}''$–$\frac{3}{16}''$	$\frac{6, 5 \& 4}{\text{Gauge}}$ or over $\frac{3}{16}''$–$\frac{1}{4}''$	$\frac{3, 2 \& 1}{\text{Gauge}}$ or over $\frac{1}{4}''$–$\frac{5}{16}''$	Over $\frac{5}{16}''$ to $\frac{3}{8}''$	Over $\frac{3}{8}''$ to $\frac{1}{2}''$
Diameter of Rivet.	$\frac{1}{4}''$	$\frac{5}{16}''$	$\frac{3}{8}''$	$\frac{1}{2}''$	$\frac{5}{8}''$	$\frac{3}{4}''$
Breadth of treble rivet. straps (chain)	. . .	$5\frac{5}{8}$	$6\frac{3}{4}$	9	$11\frac{1}{2}$	$13\frac{1}{2}$
Breadth of treble rivet. straps (reel)	. . .	5	6	8	10	12
Breadth of double rivet. straps (chain)	$3\frac{1}{4}$	4	5	$6\frac{1}{4}$	$7\frac{3}{4}$	$9\frac{1}{2}$
Breadth of double rivet. straps (reel)	3	$3\frac{3}{4}$	$4\frac{1}{2}$	$5\frac{3}{4}$	7	$8\frac{3}{4}$
Breadth of single rivet. straps	$1\frac{3}{4}$	$2\frac{1}{4}$	$2\frac{5}{8}$	$3\frac{1}{2}$	$4\frac{3}{8}$	$5\frac{1}{4}$
Breadth of treble rivet. overlap butts	$2\frac{1}{2}$	3	$3\frac{1}{2}$	$4\frac{1}{2}$	$5\frac{3}{4}$	$6\frac{3}{4}$
Breadth of double rivet. overlap butts	$1\frac{3}{4}$	$2\frac{1}{8}$	$2\frac{1}{2}$	3	$3\frac{3}{4}$	$4\frac{1}{2}$
Breadth of single rivet. overlap butts	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	$2\frac{1}{4}$	$2\frac{5}{8}$
Breadth of double rivet. lap seam	$1\frac{1}{2}$	$1\frac{7}{8}$	$2\frac{1}{4}$	3	$3\frac{3}{4}$	$4\frac{1}{2}$
Breadth of single rivet. lap seam	$\frac{7}{8}$	$1\frac{1}{8}$	$1\frac{3}{8}$	$1\frac{3}{4}$	$2\frac{1}{4}$	$2\frac{1}{2}$
Spacing in butts of shell and stringer	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3
Spacing in butts of deck	$1\frac{1}{8}$	$1\frac{3}{8}$	$1\frac{5}{8}$	$2\frac{1}{8}$	$2\frac{5}{8}$	$3\frac{1}{8}$
Spacing in edges, shell and stringer bar	$1\frac{1}{8}$	$1\frac{3}{8}$	$1\frac{5}{8}$	$2\frac{1}{8}$	$2\frac{5}{8}$	$3\frac{1}{8}$
Spacing in edges deck	$1\frac{1}{4}$	$1\frac{7}{16}$	$1\frac{3}{4}$	$2\frac{1}{4}$	$2\frac{7}{8}$	$3\frac{1}{4}$
Spacing in edges and butts of bhds. and casings	$1\frac{1}{4}$	$1\frac{9}{16}$	$1\frac{7}{8}$	$2\frac{1}{2}$	$3\frac{1}{8}$	$3\frac{3}{4}$
Spacing in frs. rev. bars, floors and beams	2	$2\frac{1}{2}$	3	4	5	6
Spacing in bhds. and casing stiffening bars	$2\frac{1}{2}$	$3\frac{1}{8}$	$3\frac{3}{4}$	5	$6\frac{1}{4}$	$7\frac{1}{2}$
Thickness in Lbs.	Up to 5 Lbs.	Over 5 to $7\frac{1}{2}$.	$7\frac{1}{2}$ to 10.	10 to $12\frac{1}{2}$.	$12\frac{1}{2}$ to $15\frac{1}{4}$.	$15\frac{1}{4}$ to $20\frac{1}{4}$.

STRENGTH OF RIVETING IN SHIPS.—* Table I

Thickness of Plate. (t).	Rivet Diameter. (d).	Rivet Hole. Diameter. (d_1).	Rivet Hole. Sectional Area. (a_1)	Mean Countersink. (d_2).	Spacing of Rivet c. to c. (s).	Ratio of Strength of Riveting to Strength of Solid Plate $=\left(\frac{8 A_1}{s \times t}\right)$. Single Rivet. Lap.	Double Rivet. Lap.	Treble Rivet. Lap.	Quad. Rivet. Lap.	Double Straps Treble Rivet.
Ins.	Ins.	Ins.	Sq. "	Ins.	Ins.					
$\frac{4}{20}$	$\frac{1}{2}$	.562	.248	.687	2	.662	1.324	...	...	...
$\frac{5}{20}$	"	"	"	"	"	.496	.992	...	...	...
$\frac{6}{20}$	$\frac{5}{8}$	.687	.370	.844	$2\frac{1}{4}$	.525	1.050	1.575	...	...
$\frac{7}{20}$	"	"	"	"	"	.440	.880	1.320	...	...
$\frac{8}{20}$	$\frac{3}{4}$	.812	.518	1.000	$2\frac{5}{8}$	.450	.900	1.350	...	...
$\frac{9}{20}$	"	"	"	"	"	.395	.790	1.185	...	...
$\frac{10}{20}$	"	"	"	"	"	.350	.700	1.050	...	...
$\frac{11}{20}$	$\frac{7}{8}$	.937	.690	1.156	$3\frac{1}{4}$	.354	.706	1.062	...	...
$\frac{12}{20}$	"	"	"	"	"	.320	.640	.960	...	...
$\frac{13}{20}$	"	"	"	"	"	.294	.588	.882	1.176	...
$\frac{14}{20}$	"	"	"	"	"	.271	.542	.813	1.084	...
$\frac{15}{20}$	1	1.002	.885	1.312	$3\frac{1}{2}$	...	.584	.876	1.168	...
$\frac{16}{20}$	"	"	"	"	"	...	.548	.822	1.094	...
$\frac{17}{20}$	"	"	"	"	"	...	.512	.758	1.024	...
$\frac{18}{20}$	"	"	"	"	"	...	.480	.720	.960	...
$\frac{19}{20}$	$1\frac{1}{8}$	1.187	1.110	1.467	$3\frac{13}{16}$	...	.500	.750	1.000	...
$\frac{20}{20}$	"	"	"	...	...	...	.474	.711	.948	...
$\frac{21}{20}$	"	"	"	...	...	...	.450	.675	.900	...
$\frac{22}{20}$	"	"	"	...	...	...	.430	.645	.860	...
$\frac{23}{20}$	"	"	"	...	...	...	.410	.615	.820	1.230
$\frac{24}{20}$	"	"	"	...	...	...	.392	.588	.784	1.176
$\frac{25}{20}$	"	"	"	...	...	...	.376	.564	.752	1.128
$\frac{26}{20}$	"	"	"	...	...	...	.360	.540	.720	1.080

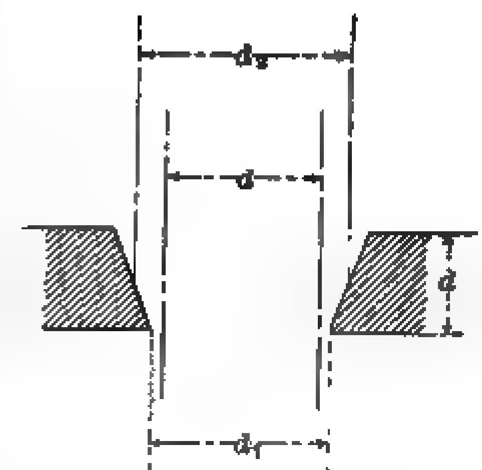


Fig. 130.

* From a paper by J. Bruhn, B.Sc., read before the Institute of Engineers and Shipbuilders in Scotland.

STRENGTH OF RIVETING IN SHIPS.—Table II. Butt Riveting.

Length of Vessel in Feet.	Breadth of Vessel in Feet.	Depth of Vessel in Feet	Thickness of Sheer-strake in Inches.	Size of Rivets in Inches.		Stress in Tons per Square Inch of Material.								
						On Plate.		On Rivets.						
						On Solid Plate	In Way of Frame Rivets.	Double Riveted Lap or Strap Rivets $3\frac{1}{2}$ Dias. Apart.	Treble Riveted Strap Alternate Rivets in Back Row Omitted. Riv. $3\frac{1}{2}$ Dias c. to c.	Treble Riveted Strap Riv. $3\frac{1}{2}$ Dias. Apart. In Back Row $5\frac{1}{2}$ Dias. Apart.	Treble Riveted Lap Rivets $3\frac{1}{2}$ Dias. Apart	Quadruple Riveted Lap. Rivets 4 Dias. Apart.	Double Straps, Treble and Double Riveted. Rivets $3\frac{1}{2}$ Dias Apart, 7 in Back Row.	Double Straps Treble Riveted. Rivets 4 Dias. Apart.
(L).	(B).	(D)	(t).	(d).	(d_1).									
100	20	8	$\frac{8}{20}$	$\frac{3}{4}$	.812	3.40	4.20	3.45	2.75	2.57	2.30	. . .	. . .	. . .
150	25	12	$\frac{10}{20}$	$\frac{7}{8}$	.937	4 20	5.20	4 78	3.80	3.55	3.16	. . .	. . .	. . .
200	30	16	$\frac{12}{20}$	"	"	4.90	6 05	. . .	5.35	5.00	4.45	3.82	. . .	. . .
250	35	20	$\frac{14}{20}$	1	1 062	5.50	6.60	. . .	6.00	5.60	5.00	4.30	3.33	. . .
300	40	24	$\frac{16}{20}$	"	"	6.00	7.40	. . .	. . .	7.05	6.25	5.35	4.17	3.57
350	45	28	$\frac{17}{20}$	"	"	6 40	7.90	. . .	. . .	. . .	7.10	6.10	4 75	4.05
400	50	32	$\frac{18}{20}$	$1\frac{1}{8}$	1.187	6.70	8.20	. . .	. . .	. . .	. . .	6.15	4.80	4.10
450	54	36	$\frac{19}{20}$	"	"	6.95	8.50	. . .	. . .	. . .	. . .	6.70	5.20	4.46
500	58	40	$\frac{20}{20}$	"	"	7.15	8.90	. . .	. . .	. . .	. . .	. . .	5 65	4.84
550	62	43	$\frac{21}{20}$	"	"	7.35	9.10	. . .	. . .	. . .	. . .	. . .	6.13	5.24
600	66	46	$\frac{22}{20}$	"	"	7.50	9.60	. . .	. . .	. . .	. . .	. . .	6.52	5.60
650	70	49	$\frac{23}{20}$	"	"	7.65	9.75	. . .	. . .	. . .	. . .	. . .	. . .	5 98
700	74	52	$\frac{24}{20}$	"	"	7.75	9.90	. . .	. . .	. . .	. . .	. . .	. . .	6.30

STRENGTH OF RIVETING IN SHIPS.—Table III. Edge Riveting.

Length of Vessel in Feet.	Displacement in Tons.	Thickness of Plating in Inches.	Size of Rivet in Inches.		Spacing of Rivet in Inches.	Stress in Tons per Square Inch of Material.													
						Due to Main Sheering Forces.		One Tier of Beams.		Two Tiers of Beams.		Three Tiers of Beams.		Four Tiers of Beams.		Five Tiers of Beams.	
						Single Riveted Edge Lap.	Double Riveted Edge Lap.	Due to Bending of Framing.	Combined Stress.	Due to Bending of Framing.	Combined Stress.	Due to Bending of Framing.	Combined Stress.	Due to Bending of Framing.	Combined Stress.	Due to Bending of Framing.	Combined Stress.
(L).	Δ.	(t).	(d).	(d_1).	(s).												
100	300	$\frac{6}{20}$	$\frac{5}{8}$	.687	2.50	1.30	...	.35	1.35	...	...	...	...	...	...	...	...
150	850	$\frac{7}{20}$	$\frac{3}{4}$	.812	3.00	2.10	...	1.00	2.32	...	...	...	...	...	...	...	...
200	1,700	$\frac{8}{20}$	"	"	3.15	3.30	...	2.66	4.25	2.12	3.92	...	...	...	...	...	...
250	3,000	$\frac{10}{20}$	$\frac{7}{8}$	.937	3.83	...	2.14	1.49	2.61	1.43	2.57	...	...	...	...	...	...
300	5,000	$\frac{11}{20}$	"	"	3.43	...	2.65	1.80	3.21	1.80	3.21	...	...	...	...	...	...
350	7,700	$\frac{12}{20}$	"	"	3.43	...	3.50	...	...	2.20	4.15	2.07	4.07	...	...	...	...
400	11,100	$\frac{13}{20}$	"	"	3.57	...	4.60	...	...	2.66	5.33	2.62	5.30	...	...	...	...
450	15,200	$\frac{14}{20}$	1	1.062	4.33	...	5.25	...	...	2.70	5.90	2.80	5.95	...	...	...	...
500	20,000	$\frac{15}{20}$	"	"	3.85	...	5.50	...	...	...	...	...	...	2.08	5.90	...	...
550	24,000	$\frac{16}{20}$	"	"	4.00	...	6.35	...	...	...	...	...	...	2.31	6.75	...	...
600	28,300	$\frac{17}{20}$	"	"	4.15	...	7.30	...	...	...	...	...	...	3.50	8.10	...	...
650	33,000	$\frac{18}{20}$	$1\frac{1}{8}$	1.187	5.00	...	7.75	...	...	...	...	...	...	...	...	2.64	8.18
700	38,000	$\frac{19}{20}$	"	"	4.43	...	7.40	...	...	...	...	...	...	...	...	2.55	7.85

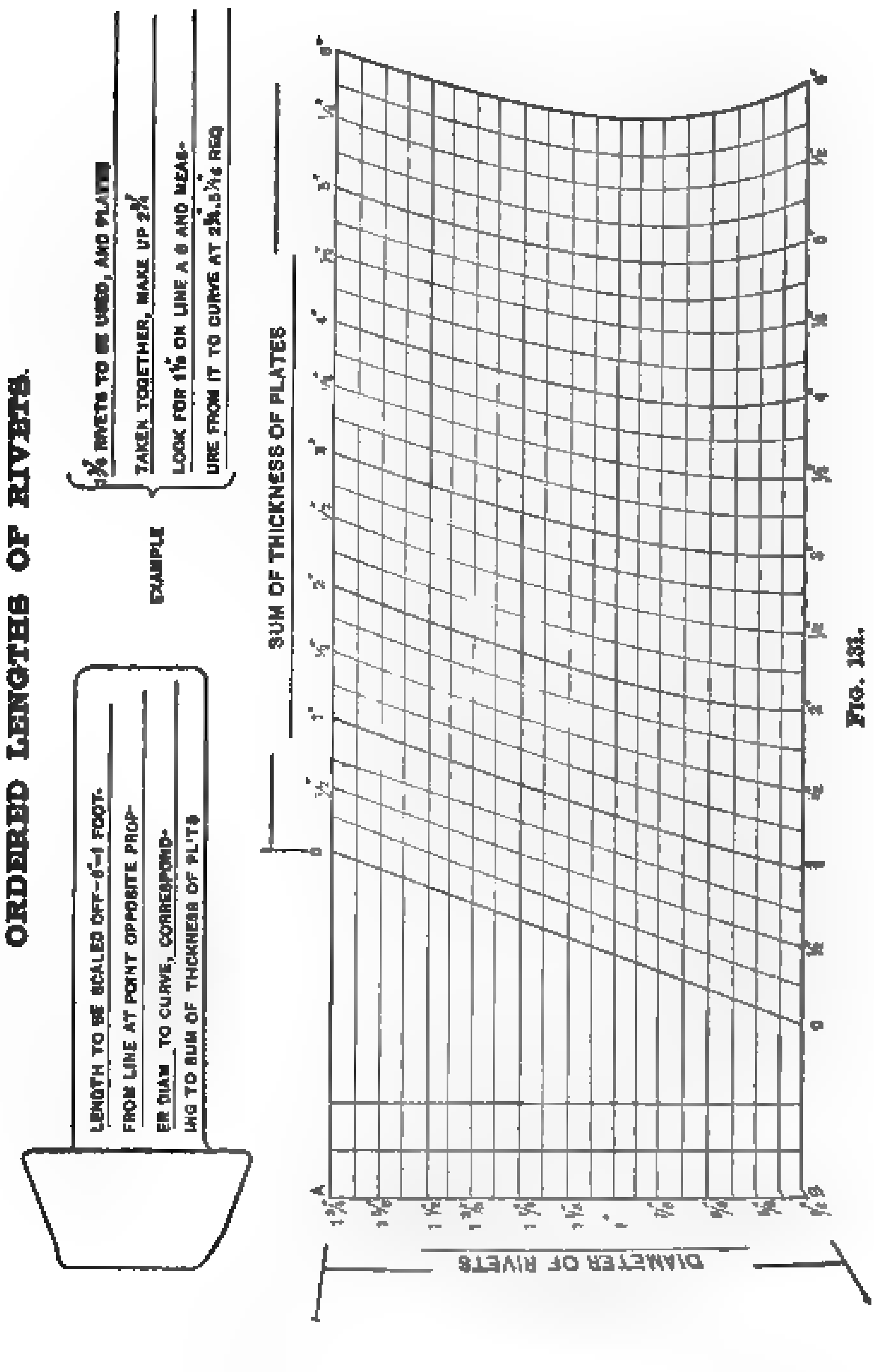

ORDERED LENGTHS OF RIVETS
LENGTH TO BE SCALED OFF—6"=1 FOOT—
FROM LINE AT POINT OPPOSITE PROP-
ER DIAM TO CURVE, CORRESPOND-
ING TO SUM OF THICKNESS OF PL'TS
EXAMPLE
TAKEN TOGETHER, MAKE UP
SUM OF THICKNESS OF PLATES
DIAMETER OF RIVETS

Fig. 131.

STRENGTH OF

Table IV. —

Length of Vessel in Feet.	Thickness of Plating in Inches.	Spacing of Frames in Inches.	Rivet in Frames and Outside Plating. Diameter of Rivets in Inches.	Diameter of Hole in Inches	Spacing of Rivets in Inches.	One Tier of Beams. Frame.	Reverse Frame.	Stress in Tons per Square Inch.	Two Tiers of Beams. Frame.	Reverse Frame.	Stress in Tons per Square Inch.
(L).	(t).		(d)	(d_1).		Inches.	Inches.		Inches.	Inches.	
100	$\frac{6}{20}$	20	$\frac{5}{8}$	.687	4.50	$2\frac{1}{2}\times2\frac{1}{2}\times\frac{6}{16}$	None.	.93	. . . . .	. . . . .	. .
150	$\frac{7}{20}$	21	$\frac{3}{4}$	.812	5.25	$3\times3\times\frac{6}{16}$	$2\frac{1}{2}+2\frac{1}{2}-\frac{6}{16}$ Alternately	1.50	. . . . .	. . . . .	. .
200	$\frac{8}{20}$	22	"	"	"	$4\frac{1}{2}\times3\times\frac{7}{16}$	$4\times3\times\frac{7}{16}$	3.06	$3\frac{1}{2}\times3\times\frac{7}{16}$	$3\times2\frac{1}{2}\times\frac{6}{16}$	4.30
250	$\frac{10}{20}$	23	$\frac{7}{8}$	.937	6.25	$5\times3\times\frac{7}{16}$	$5\times3\times\frac{7}{16}$	2.83	$4\frac{1}{2}\times3\times\frac{7}{16}$	$3\times3\times\frac{7}{16}$	4.10
300	$\frac{11}{20}$	24	"	"	"	$6\times3\frac{1}{2}\times\frac{8}{16}$	$5\frac{1}{2}\times3\frac{1}{2}\times\frac{8}{16}$	3.30	$5\frac{1}{2}\times3\frac{1}{2}\times\frac{8}{16}$	$4\times3\frac{1}{2}\times\frac{8}{16}$	4.60
350	$\frac{12}{20}$	24	"	"	"	. . . . .	. . . .	. .	$6\times3\frac{1}{2}\times\frac{8}{16}$	$6\times3\frac{1}{2}\times\frac{8}{16}$	4.80
400	$\frac{13}{20}$	25	"	"	"	. . .	. . . .	. .	$6\frac{1}{2}\times3\frac{1}{2}\times\frac{10}{16}$	$6\frac{1}{2}\times3\frac{1}{2}\times\frac{10}{16}$	4.80
450	$\frac{14}{20}$	26	1	1.062	7.00	. . . . .	. . . .	.	$7\frac{1}{2}\times3\frac{1}{2}\times\frac{10}{16}$	$7\times3\frac{1}{2}\times\frac{10}{16}$	4.00
500	$\frac{15}{20}$	27	"	"	6.50	. . . . .	. . . .	. .	. . . . .	. . . . .	. .
550	$\frac{16}{20}$	28	"	"	"	. . . .	. . . . .	.	. . . . .	. . . . .	. .
600	$\frac{17}{20}$	29	"	"	6.00	. . . . .	. . . .	. .	. . . . .	. . . . .	. .
650	$\frac{18}{20}$	30	$1\frac{1}{8}$	1.187	6.75	. . . . .	. . . . .	.	. . . . .	. . . .	. .
700	$\frac{19}{20}$	31	"	"	"	. . . .	. . . .	. .	. . . . .	. . . . .	. .

RIVETING IN SHIPS.

Frame Riveting.

Three Tiers of Beams.			Four Tiers of Beams.			Five Tiers of Beams.		
Frame.	Reverse Frame.	Stress in Tons per Square Inch.	Frame.	Reverse Frame.	Stress in Tons per Square Inch.	Frame.	Reverse Frame.	Stress in Tons per Square Inch.
Inches.	Inches.		Inches.	Inches.		Inches.		
.....	.....	..	....	.....	..	......	....	..
.....	.....	..	....	.....	..	......	....	..
.....	.....	..	....	.....	..	......	....	..
.....	.....	..	....	.....	..	......	....	..
.....	.....	..	....	.....	..	......	....	..
$5\frac{1}{2}\times3\frac{1}{2}\times\frac{9}{20}$	$4\times3\frac{1}{2}\times\frac{9}{20}$	6.90	....	.....	..	......	....	..
$6\times3\frac{1}{2}\times\frac{10}{20}$	$4\frac{1}{2}\times3\frac{1}{2}\times\frac{10}{20}$	6.70	....	.....	..	......	....	..
$7\times3\frac{1}{2}\times\frac{10}{20}$	$4\frac{1}{2}\times4\times\frac{10}{20}$	5.55	....	.....	..	......	....	..
.....	.....	..	$8\times3\frac{1}{2}\times3\frac{1}{2}\times\frac{13}{20}$	None.	5.90	......	....	..
.....	.....	..	$8\times3\frac{1}{2}\times3\frac{1}{2}\times\frac{13}{20}$	"	5.55	......	....	..
.....	.....	..	$8\times4\times4\times\frac{13}{20}$	$4\times4\times\frac{13}{20}$ Alternately.	6.62	......	....	..
.....	.....	..	....	.....	..	$9\times4\times4\times\frac{13}{20}$	None	6.15
.....	.....	..	....	.....	..	$9\times4\times4\times\frac{15}{20}$	"	6.00

SHEARING AND BEARING

ALL DIMENSIONS

Diameter of Rivet (In.). Fraction.	Diameter of Rivet (In.). Decimal.	Area in Sq. In.	Single Shear at 6,000 Lbs.	Bearing Value for ¼	Bearing Value for 5/16	Bearing Value for ⅜	Bearing Value for 7/16
⅜	.375	.1104	660	1,130	1,410	1,690	. . .
½	.500	.1963	1,180	1,500	1,880	2,250	2,630
⅝	.625	.3068	1,840	1,880	2,340	2,810	3,280
¾	.750	.4418	2,650	2,250	2,810	3,380	3,940
⅞	.875	.6013	3,610	2,630	3,280	3,940	4,590
1	1.000	.7854	4,710	3,000	3,750	4,500	5,250

Diameter of Rivet (In.). Fraction.	Diameter of Rivet (In.). Decimal.	Area in Sq. In.	Single Shear at 7,500 Lbs.	Bearing Value for ¼	Bearing Value for 5/16	Bearing Value for ⅜	Bearing Value for 7/16
⅜	.375	.1104	830	1,410	1,760	2,110	. . .
½	.500	.1963	1,470	1,880	2,340	2,810	3,280
⅝	.625	.3068	2,300	2,340	2,930	3,520	4,100
¾	.750	.4418	3,310	2,810	3,520	4,220	4,920
⅞	.875	.6013	4,510	3,280	4,100	4,920	5,740
1	1.000	.7854	5,890	3,750	4,690	5,620	6,560

Diameter of Rivet (In.). Fraction	Diameter of Rivet (In.). Decimal.	Area in Sq. In.	Single Shear at 10,000 Lbs.	Bearing Value for ¼	Bearing Value for 5/16	Bearing Value for ⅜	Bearing Value for 7/16
⅜	.375	.1104	1,100	1,880	2,340	2,810	. . .
½	.500	.1963	1,960	2,500	3,130	3,750	4,380
⅝	.625	.3068	3,070	3,130	3,910	4,690	5,470
¾	.750	.4418	4,420	3,750	4,690	5,630	6,560
⅞	.875	.6013	6,010	4,380	5,470	6,570	7,660
1	1.000	.7854	7.850	5,000	6,250	7,500	8,750

Diameter of Rivet (In.). Fraction.	Diameter of Rivet (In.). Decimal.	Area in Sq. In.	Single Shear at 12,000 Lbs.	Bearing Value for ¼	Bearing Value for 5/16	Bearing Value for ⅜	Bearing Value for 7/16
⅜	.375	.1104	1,320	2,350	2,930	3,520	. . .
½	.500	.1963	2,360	3,130	3,910	4,690	5,470
⅝	.625	.3068	3,680	3,910	4,880	5,860	6,840
¾	.750	.4418	5,300	4,690	5,860	7,030	8,210
⅞	.875	.6013	7,220	5,470	6,840	8,210	9,580
1	1.000	.7854	9,430	6,250	7,820	9,380	10,940

In above tables all bearing values above or to right of upper zigzag lines *are greater* than double shear. Values between upper and lower zigzag

VALUE OF RIVETS.

.IN INCHES.

Different Thicknesses of Plate in In. at 12,000 Lbs. per Sq. In.								
$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1
...	...	...	...	...	...	...	...	...
3,000	...	...	...	...	...	...	...	...
3,750	4,220	4,690	...	...	...	...	...	...
4,500	5,160	5,630	6,190	6,750	...	...	...	...
5,250	5,910	6,560	7,220	7,880	8,530	9,190	9,840	...
6,000	6,750	7,500	8,250	9,000	9,750	10,500	11,250	12,000

Different Thicknesses of Plate in In. at 15,000 Lbs. per Sq. In.								
$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1
...	...	...	...	...	...	...	...	...
3,750	...	...	...	...	...	...	...	...
4,690	5,280	5,860	...	...	...	...	...	...
5,630	6,330	7,030	7,720	8,440	...	...	...	...
6,560	7,380	8,200	9,030	9,850	10,670	11,480	12,300	...
7,500	8,440	9,380	10,310	11,250	12,190	13,130	14,060	15,000

Different Thicknesses of Plate in In. at 20,000 Lbs. per Sq. In.								
$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1
...	...	...	...	...	...	...	...	...
5,000	...	...	...	...	...	...	...	...
6,250	7,030	7,810	...	...	...	...	...	...
7,500	8,440	9,380	10,310	11,250	...	...	...	...
8,750	9,840	10,940	12,030	13,130	14,220	15,310	16,410	...
10,000	11,250	12,500	13,750	15,000	16,250	17,500	18,750	20,000

Different Thicknesses of Plate in In. at 25,000 Lbs. per Sq. In.								
$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1
...	...	...	...	...	...	...	...	...
6,250	...	...	...	...	...	...	...	...
7,810	8,790	9,770	...	...	...	...	...	...
9,380	10,550	11,720	12,890	14,060	...	...	...	...
10,940	12,310	13,670	15,040	16,410	17,770	19,140	20,510	...
12,500	14,060	15,630	17,190	18,750	20,320	21,880	23,440	25,000

lines are less than double and greater than single shear. Values below and to left of lower *zigzag lines* are less than single shear.

SECTION III.

DETAILS, STRUCTURAL.

KEELS.

IN steel ships the keel is invariably one of the three forms of bar, flat plate or side bar, the first and third being almost entirely superseded by the flat plate type which is on all points a much better method of construction than the others, besides having the great advantage of saving from 6 to 12 inches of draft, thereby increasing the dead weight carrying capacity from about 15 to 1,500 tons respectively on a given immersion. Bar keels should have no place in modern ship construction, unless when required for rubbing purposes only.

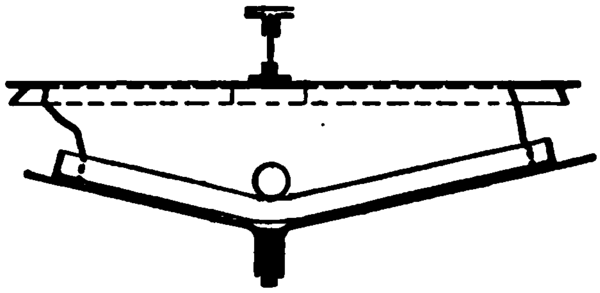


FIG. 132.

Bar Keels.

These should be made of rolled steel universal bar in preference to the old-fashioned scrap iron forgings and scarphed together in long lengths by right and left-handed scarphs. The scarphs are mostly made nine times the thickness of the bar in length, and the jog, or check, and point should be one fourth the thickness. Scarphs of keel should be close fitting and for that reason must be machined, the connection holes for rivets are drilled, and in addition a few holes, about one third the number of regular ones, should

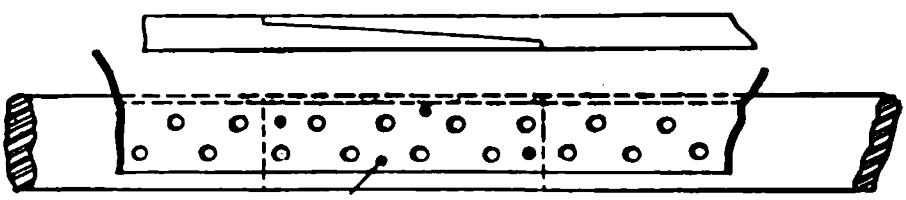


FIG. 133.

be drilled of smaller diameter, but countersunk on both sides, for tacking the various lengths together before erecting and riveting the garboard strakes. Care should be taken that these scarphs are shifted well clear of the garboard strake and centre keelson butts and that the joints of scarphs are caulked watertight.

The diameter of the rivets should be in accordance with the requirements of the riveting tables given on p. 260, and staggered as shown. The vertical spacing requires special care in keeping clear of the radius of garboard plate and also the caulking edge of same at bottom, which is raised about half an inch from lower edge of bar. For this reason it is advisable to set off the bar full size, drawing in the flanges of garboards before fixing on centres of rivet holes.

Flat Plate Keels.

Keels of this type are made of a thick plate forming the bottom member of a girder of which the centre keelson is the web. The forms mostly in use are shown by the Figs. 134 and 135. Fig. 136

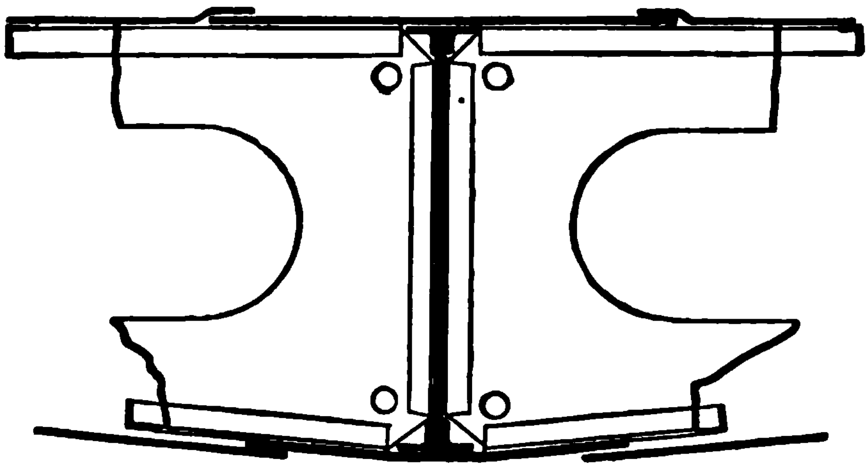


FIG. 134.

shows a very efficient and economical form of flat plate keel and centre keelson devised by the author and designed with a structural *I* section for small and moderate sized vessels with ordinary floor construction. Where a suitable *I* section is not obtainable the same construction may be retained with advantage with built-up section.

The flat plate keel should always be arranged as an inside strake, as by so doing the keel and its sister member may be laid on the

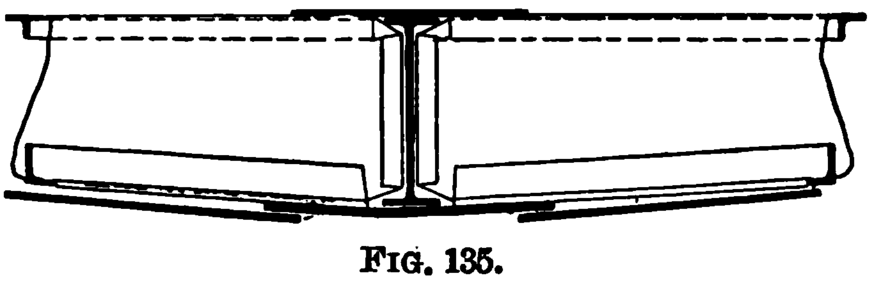


FIG. 135.

keel blocks right away without anticipating linering in addition to making a more solid job and saving a small amount of draught. It is a fallacy to place it outside with the intention of disturbing

only one plate in the event of damage — a remote contingency which should not be allowed to interfere with good construction.

Where a doubling is required by the classification societies' rules it will be found advantageous, where practicable, to increase the plate keel to a sectional area equivalent to that of the keel and doubling, and if double buttstrap be required, the inside one may be fitted in two pieces.

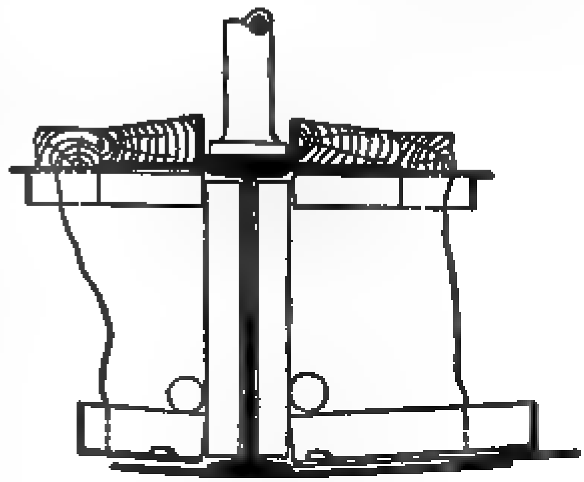


FIG. 136.

Scantlings and riveting will be as specified or to rule requirements.

At the forward and after ends the keel plate must efficiently incorporate with the stem and stern frame respectively, a short "breeches" plate being usually worked for this purpose. In small construction a "spoon" plate is welded to the bottom of stem bar in lieu of the short plate referred to, and a similar plate of "gutter" form welded to stern frame.

STEMS.

The remarks on bar keels apply equally as regards details to stems. The classification societies' rules allow a reduction in

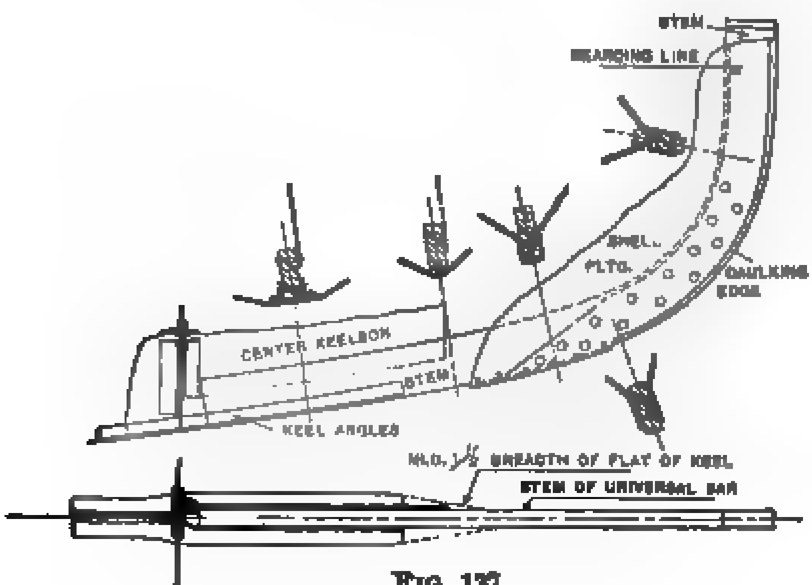


FIG. 137.

sectional area at stem heads, but as the practice is now to make the stem from universal rolled bar, it will prove no economy to taper it. The usual method of connecting lower part of stem to keel plate are shown by Fig. 137. In straight stems the profile line should be cambered about $\frac{3}{8}''$ to $\frac{3}{4}''$ from where it joins the forefoot curve to stem head, to guard against the illusion of the contour line *appearing* hollow.

STERN FRAME.

These frames are mostly forged or cast in steel in one piece for small and moderate sized steamers, and in two or more parts for the larger vessels. As in the case of stems, bar keels, etc., the scantlings are determined from the corresponding numeral of the societies' rules to which the ship is being constructed. The two posts comprising the stern frame, viz., rudder and body posts with the joining arch, are of similar scantlings, but the keel piece connecting the posts at bottom while of the same sectional area as the posts, is flattened out to allow of the keel line being curved upwards to the clump for keel pintle bearing of rudder for protection to the latter in the event of grounding.

Gudgeons are forged on the rudder post of frame from 4 to $5\frac{1}{2}$ feet apart to take the pintles; one, or two in large vessels, being so shaped as to engage the rudder stop at hard-over. This post is connected to the main structure on a deep transom plate clipped to its fore side, and in vessels of over about 300 feet in length the forward or body post must also be carried up and secured in a similar manner. The body post is swelled around the stern tube, having a sectional area through the eye equal to the frame and meeting the post above and below in a fair curve; the spur or keel part of frame must not be too long to facilitate handling, the general rule being about $2\frac{1}{2}$ frame spaces before the body post, where it incorporates with, or scarphs into, the keel as already described.

In steamers over 350 feet length where these frames are of considerable weight, the riveting connecting body post to hood ends of shell plating should be treble below boss and of increased diameter and an addition made to the plating thickness. As in the keels, these holes must be carefully drilled and where scarphs are introduced as in the case of frames of two or more pieces the riveted connection should be developed to equal the bar. It is common to make the contour of body post curvilinear, thus effecting an appreciable saving in weight over the straight line, besides giving a more graceful form.

In small steamers the after or rudder post may be dispensed *with, a spur being* carried aft from body post to support heel pintle.

For single screw steamers classed to Lloyds the weight of stern frame may be very closely approximated by taking the first numeral to upper deck and multiplying it by 240 for vessels over 300 feet in length, or by 155 for those under this dimension, as first number × 240 = weight in pounds.

RUDDERS.

Some of the more common forms of rudders are shown in Figs. 138 to 143. The stresses to which they are subjected and the method of determining the diameter of stock has already been fully described. The single plate rudder, Fig. 138, is the type most commonly adopted in merchant steamers, and is usually built in three parts, viz.: the frame, norman head and plate. The frame may be either cast or forged, having arms or stays projecting from the stock on alternate sides of centre line spaced opposite each of the gudgeons, which are from 4′ to 5′ 6″ apart.

The norman head or stock should be forged in iron or steel with a coupling palm at lower end to connect with a similar palm on head of frame. Allowance should be made on this forging for machining a key to lock the norman head to the frame, and in addition turned coupling bolts are fitted with nuts on *under* side, threads turned off to a thimble point and split pins fitted. These bolts are from one to three inches in diameter in practice. Their size, however, is not important, as the shearing stresses are all taken on the key. The stock need only be turned in wake of the rudder quadrant where it is sometimes increased in diameter to compensate for cutting the keyway.

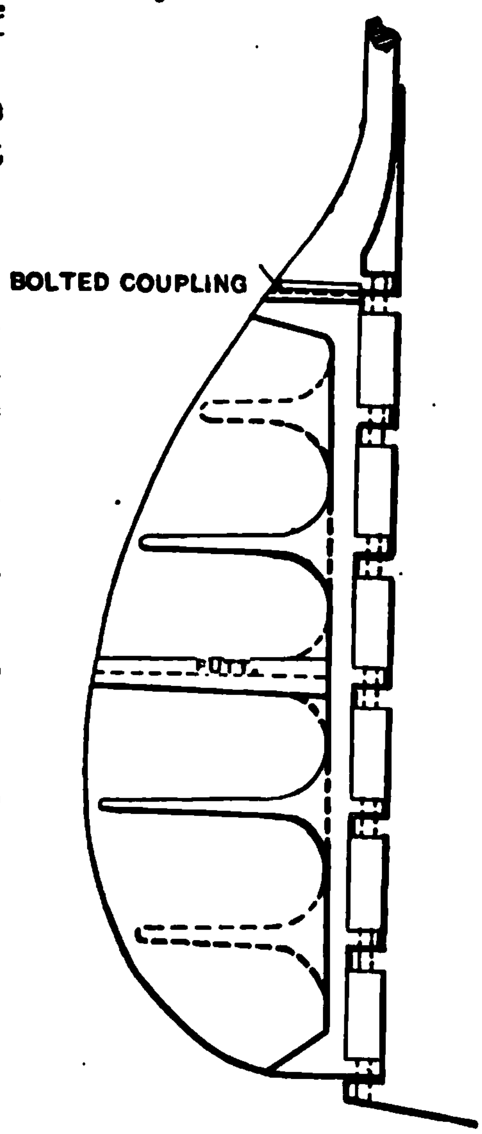


FIG. 138.

The single plate forming the rudder blade is fitted between, and riveted to, the supporting arms, besides engaging a groove cut down the back of rudder stock. Its thickness ranges from about ⅝″ in small steamers to 1¼ inches in liners.

Braces are formed at the ends of supporting arms which are turned out to take fitted pintles. One (two in large rudders) of these braces must be shaped to act as a stopper when the rudder is put hard-over. The pintles should preferably be fitted

separately and of the cone type shown in the detail. It is bad practice to forge pintles on the frame, as besides the difficulty of turning them in a lathe they have the disadvantage of not being readily renewable. The best manner of bushing the pintles is a matter of opinion, the simplest and probably the one most favored being to make the bushes of hard steel with a flange to take the tap screws securing them around the eye of the braces. The weight of the rudder in small vessels is taken on a hard steel disc placed in the heel step bearing with a hole through the heel step

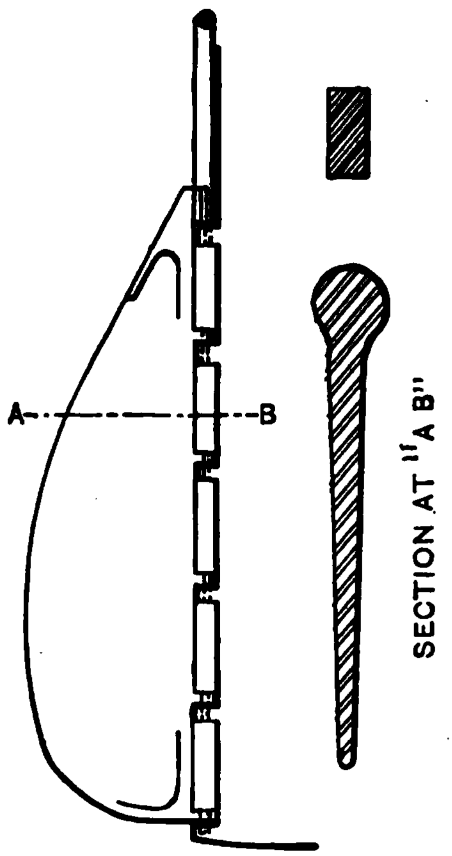


FIG. 139.

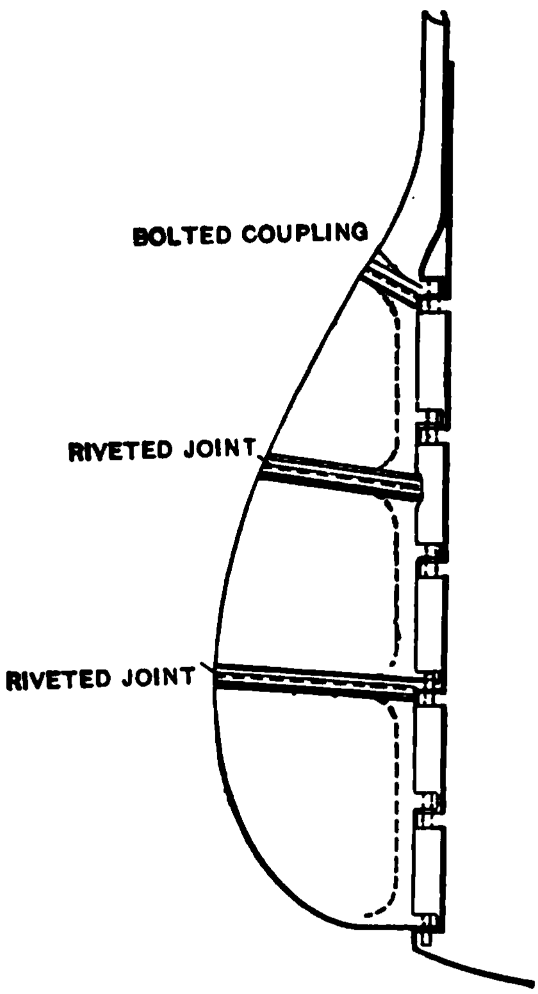


FIG. 140.

for backing it out. In large steamers, however, where the weight of rudder is many tons, the weight should always be taken by a carrier seated inside the counter. Various types of these are shown by engravings 144 to 146. Provision must be made on the back of rudder well clear of water line to fit a jew's harp shackle for securing the emergency chains, which are from thence carried up the counter, being stopped with ratline stuff to tapped eyes spaced about thirty inches apart.

Next in favor to the single plate is the cast steel rudder, Fig. 139, although where only one is being made its cost is against it. For the largest sizes its difficulty of successful manufacture is also to

its disadvantage, although this is got over by casting it in two or more pieces, see Fig. 140, keying these together and riveting them through coupling flanges. When rudders are designed to be cast in one piece, the ribs which are cast on the blade to act as stays should be of easy section, so as not to interfere more than necessary with the contraction of the casting in cooling.

The oldest method of making the rudder for steel ships is the built type, Fig. 142, which consists of a forged frame having stock, stays, and back piece in one, with two side plates riveted to same

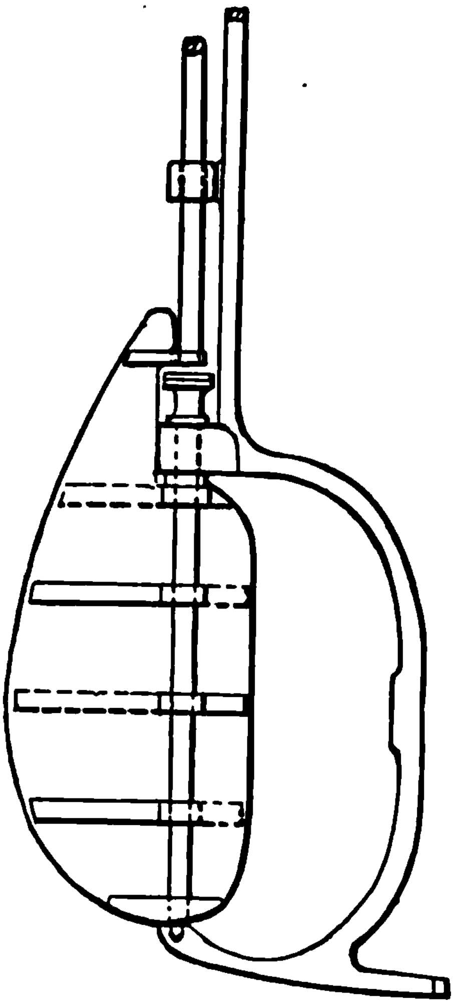


FIG. 141.

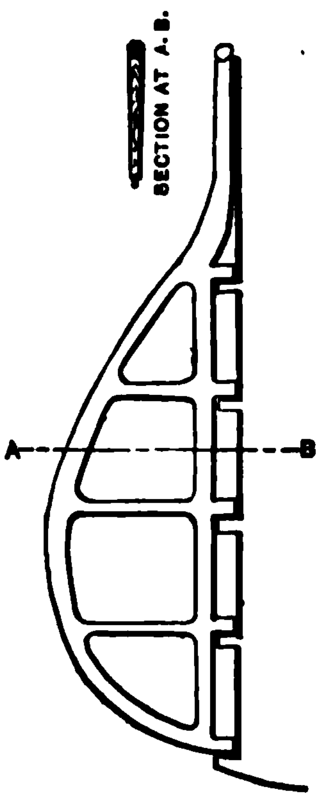


FIG. 142.

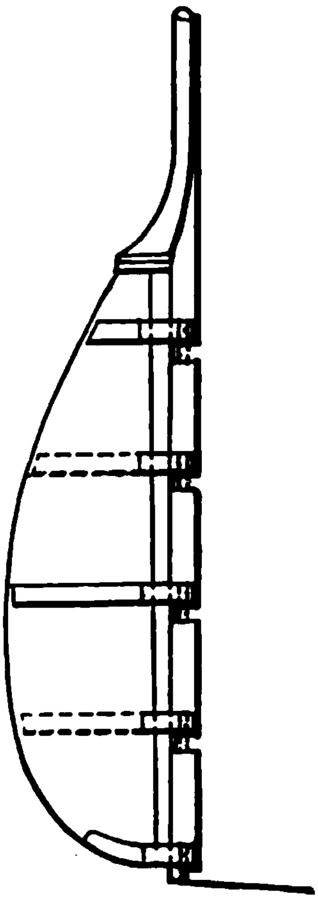


FIG. 143.

after having the inside filled in with fir coated with tar. Its great objection is the cost of forging, especially for large rudders. It has gone completely out of favor unless for yachts, where its appearance commands its use, and in light craft of the torpedo boat kind where sufficient stiffness would not be obtainable in a single plate without going into a thickness which would make the weight prohibitive. It is also often used with the frame cast in gun metal and the side plates of 16 gauge brass sheet, for wood speed launches, vedettes, pinnaces, etc., although for these craft a cheaper and lighter rudder may be obtained by casting it complete in gun metal or bronze.

RUDDER CARRIER

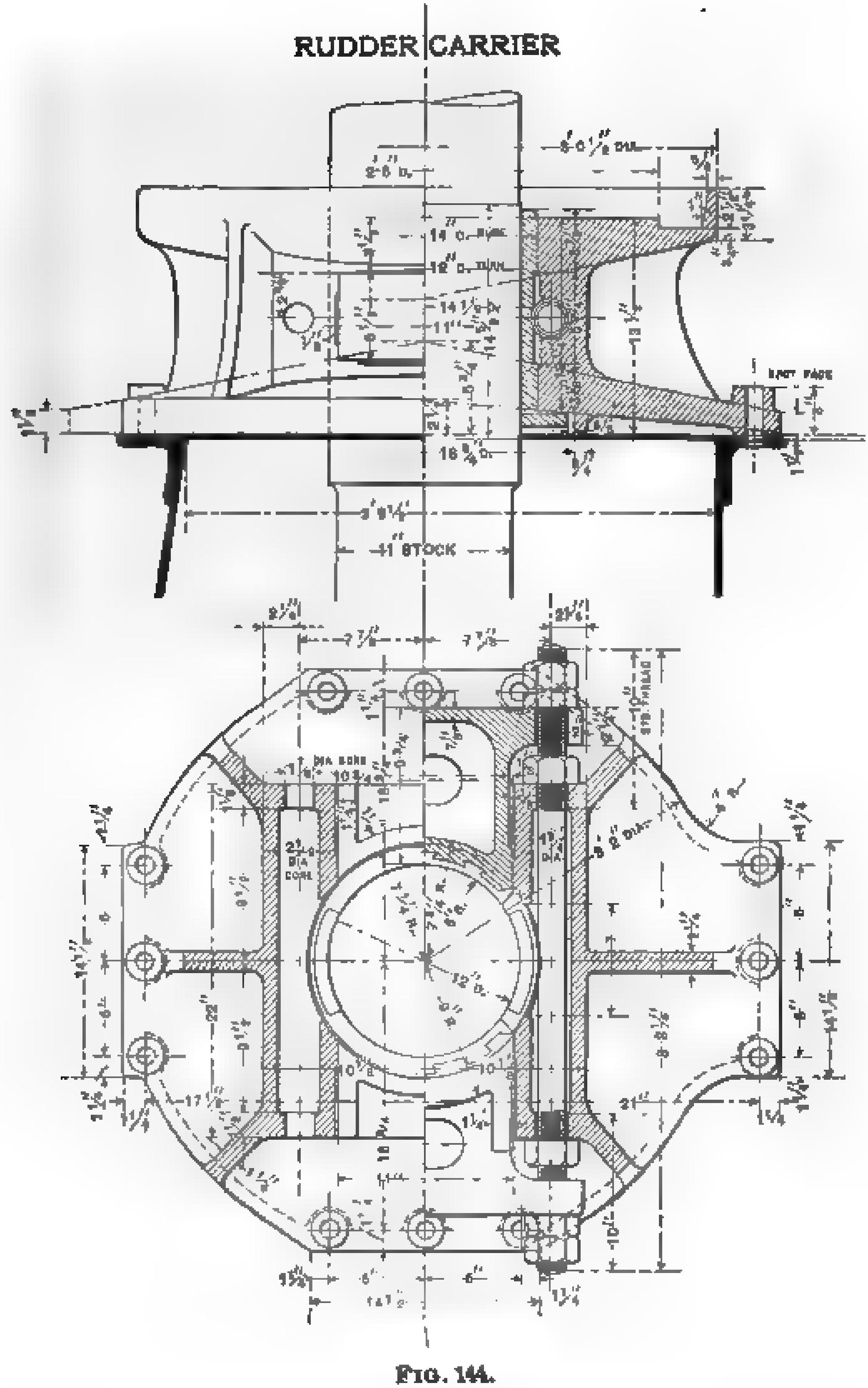


Fig. 144.

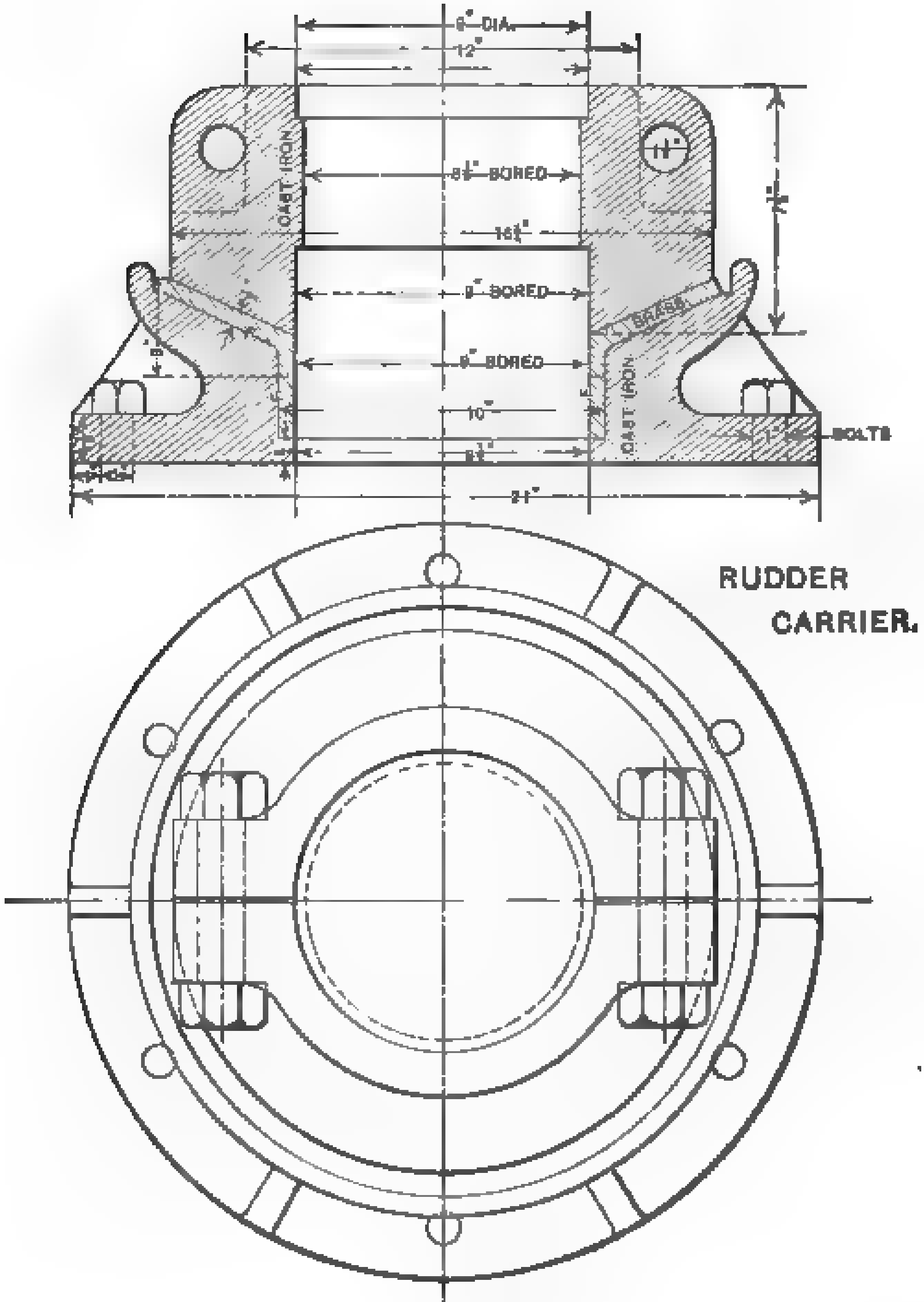

12"
CAST IRON
BORED
BORED
BRASS
BORED
10"
CAST IRON
BOLTS
21"
RUDDER
CARRIER.

FIG. 145.

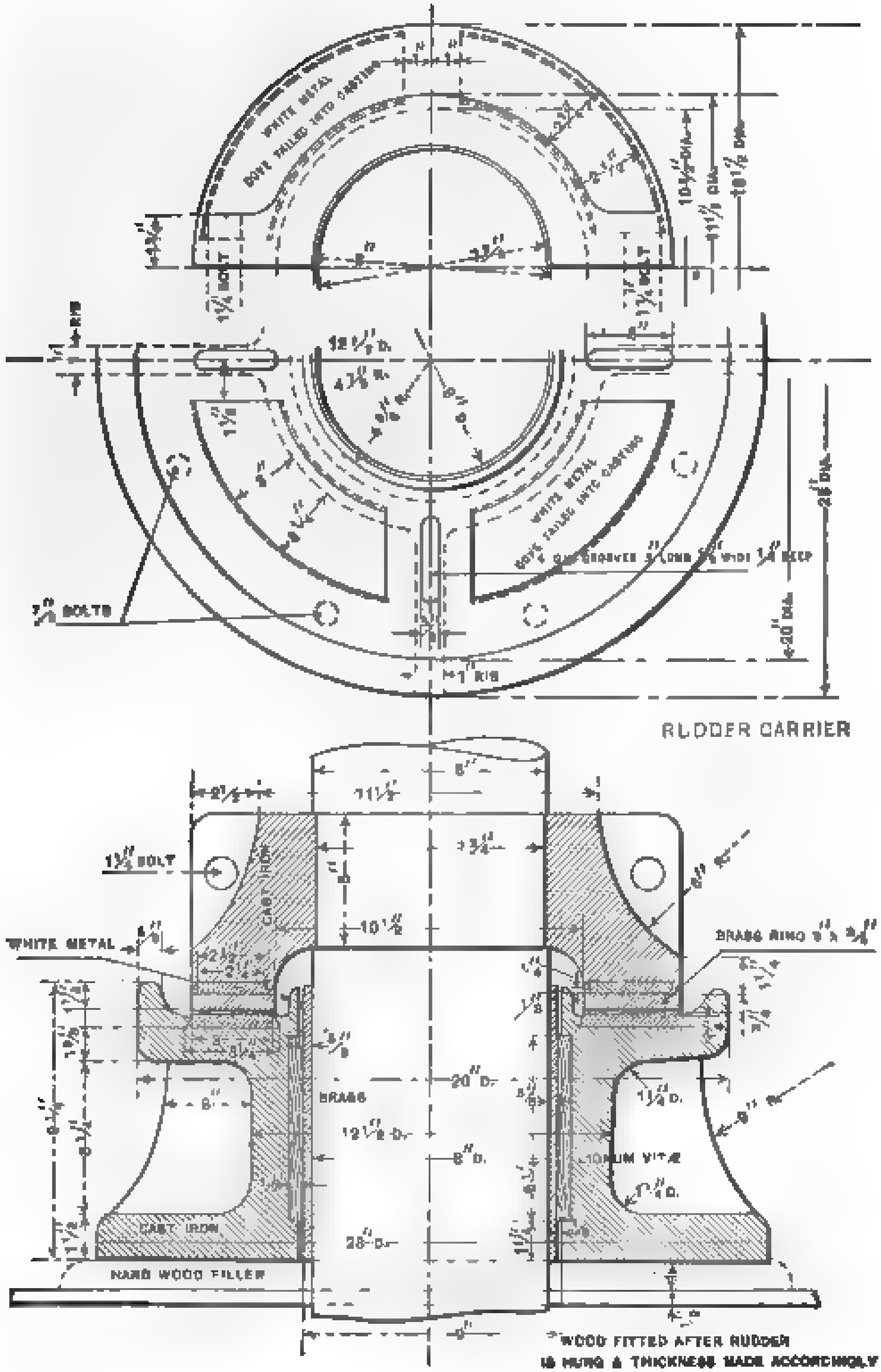

WHITE METAL
DOVE TAILED INTO CASTING
$\frac{7}{8}''$ BOLTS
RUDDER CARRIER
$1\frac{3}{4}''$ BOLT
CAST IRON
WHITE METAL
BRASS RING
BRASS
LIGNUM VITÆ
CAST IRON
HARD WOOD FILLER
WOOD FITTED AFTER RUDDER
IS HUNG & THICKNESS MADE ACCORDINGLY

FIG. 146.

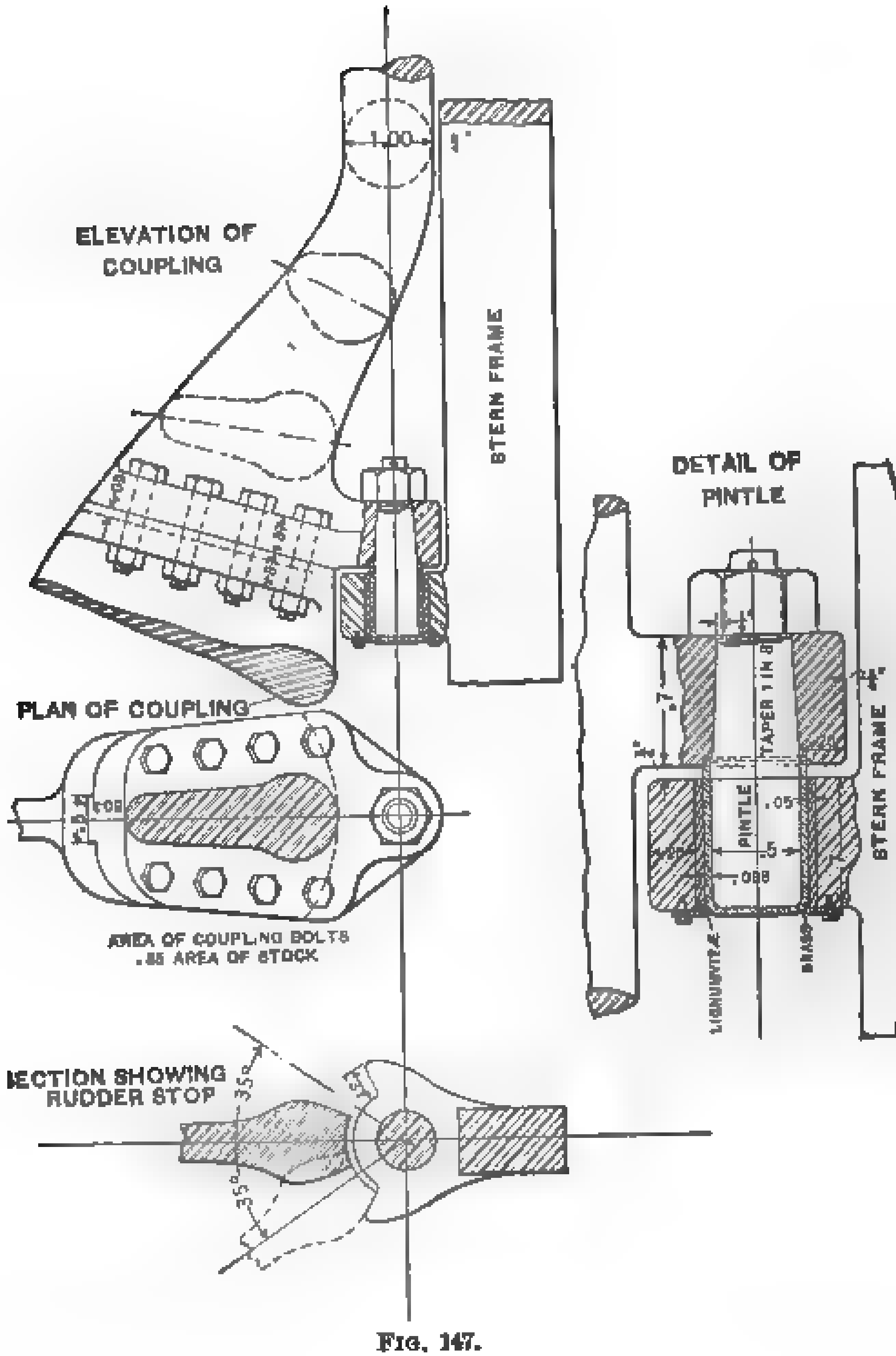

ELEVATION OF COUPLING
STERN FRAME
1.00
DETAIL OF PINTLE
TAPER 1 IN 8
PINTLE
STERN FRAME
LIGNUMVITAE
BRASS
PLAN OF COUPLING
AREA OF COUPLING BOLTS
.85 AREA OF STOCK
SECTION SHOWING
RUDDER STOP
35°

FIG. 147.

Where the rudder stock enters the vessel, watertightness must be ensured by fitting a trunk having a stuffing box and gland at its top. This latter, however, may be dispensed with where a carrier is arranged for, this being an additional element in favor of the adoption of these supports. Before fixing on the counter dimension of the rudder trunk, care should be taken that ample clearness is given to ship and unship the rudder. It will be seen, therefore, that the hole through the counter is much in excess of the diameter of stock, and if not filled in would be unsightly, besides allowing a considerable volume of water continually at play inside. It is covered in with a tail plate fitted in halves and secured with hexagon head taps to the counter plating, so as to be easily removable to permit of unshipping the rudder.

Good proportions for such details as pintles, gudgeons, braces, couplings, etc., to meet most requirements are shown in Fig. 147.

PROPELLER STRUTS.

These brackets for supporting the outer end of tail shaft are generally of pear-shaped section as being the form of least resistance. It is usual to cast them in steel, although they are also sometimes built up.

In selecting a suitable area of arm shipbuilders are guided mostly by experience, hence the divergent results seen in practice. The author has therefore devised the formula given on p. 109, in which he has attempted to secure a uniform relationship between the size of these struts and the power transmitted through them.

Where possible the centre of the propeller bracket should be placed on a frame to obtain the maximum of stiffness, and the palms of upper and lower arms may be cast on or connected with angle clips. A web spur is sometimes cast or worked on keel length of stern post to take the palm of lower arm instead of flanging the latter and riveting it through the keel to it, securing independent connection for each strut.

In wake of the upper palm additional stiffening must be worked by fitting a short local doubling on shell and a stringer inside. The number and diameter of palm fastenings should be developed according to the sectional area of the arm, these being in most cases overdone.

The sectional area of arms must not be tapered towards the boss, as, although theoretically considered as a cantilever, this would be rational, it must not be lost sight of that the greatest stresses are borne by the ends of the arms adjoining the boss, and are, besides, alternating ones inducing fatigue.

The engineer will determine the length of boss barrel suitable *for bearing* and also the finished diameter of the hole, but ample

allowance should be made for boring out to this dimension and also *adjusting* to centre line of shaft; this is most important when dealing with cast steel, as it provides the opportunity to detect hidden blow holes. A mass of metal should be avoided where the arm swells to meet the boss either by reducing the fillet to a minimum or coring out the metal inside the boss, as otherwise internal stresses will be set up in cooling or dangerous blow holes developed.

In high speed vessels it is important to make the pattern "wind" conforming to the run of the water line, thus obviating the arms being dragged across the stream lines and creating eddies. It is surprising the amount of power absorbed by this resistance when brackets are badly set or not set at all.

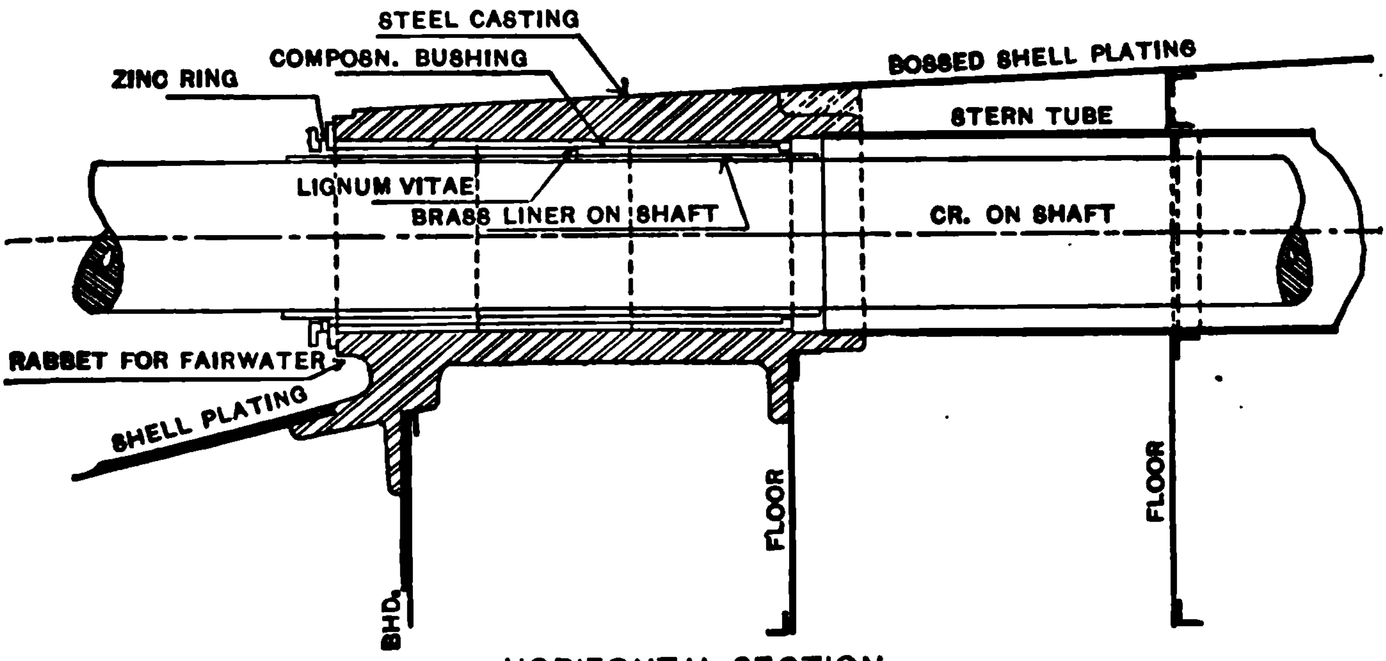
SPECTACLE FRAMES.

Spectacle frames have nearly superseded the open A brackets for large merchant vessels. They are enveloped in the hull of the ship, the plating being webbed out and bossed around the shaft for this purpose, as fully explained in the chapter on Design, which see.

Where the plating ends on the arms of these frames a good riveted connection must be made, usually double and increased to treble tap rivets around the boss. Local strengthening must also be fitted in wake of spectacle frames by increasing the deep floors in thickness and doubling the ship's frames in their vicinity.

CASTING AT STERN TUBE.

The outboard end of stern tube in vessels fitted with A brackets is supported by and connected to a steel casting or forging. Its function is similar to the boss on body post of a single screw steamer.



HORIZONTAL SECTION.

FIG. 148.

In large steamers it is usual to extend this casting over two frames in length to give additional support, as shown in Fig. 148, but in small vessels the tube end support need only be from 2 to 4 inches thick, and shaped like Fig. 149. Usually a watertight bulkhead is fitted at the forward and after ends of the stern-tube, the former one being bossed and spectacled at the wings in the manner depicted in the detail given.

The inboard palm of the tube end forging is securely riveted to

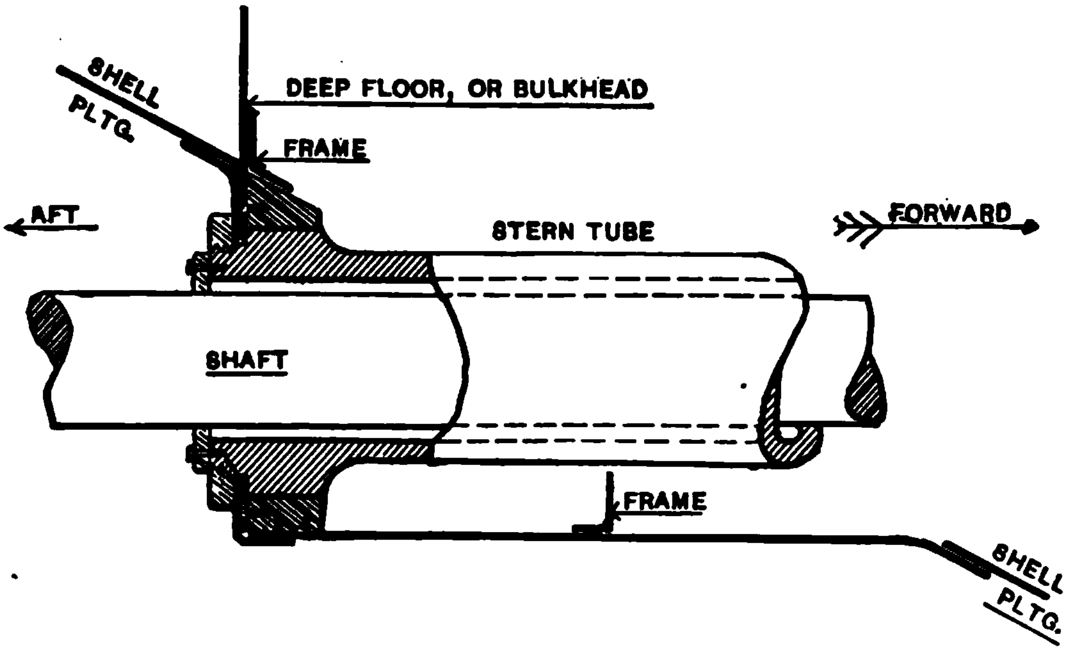


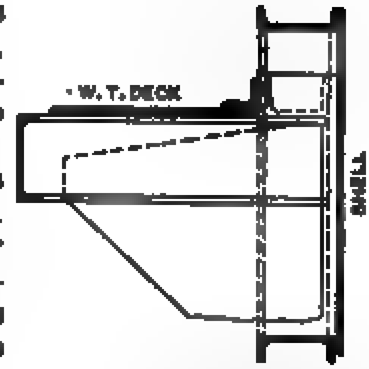
FIG. 149.

wing plate of bulkhead, which must be increased in thickness for the heavier riveting necessarily employed for this purpose.

FRAMING.

In ships having ordinary floors the frames are invariably run in one piece from centre line to gunwale, and where channel bars or bulb angles are employed with this construction, the floor plates may be reduced in consideration of the excess strength given in their wake. Vessels having a double bottom on the cellular system need only have angle frames on the deep floors with flanges sufficient to take the size of riveting required. Forward in the flat of bottom in full vessels these should be doubled inside tank and in addition local fore and aft stiffening fitted to reënforce against "pounding." Where vessels are classed, as they mostly are, the scantlings of the frames are obtained from the rules of the classification bureau. The angle bars of which they are made is always one with unequal legs, the larger flange standing vertically to the shell plating to obtain the greatest section modulus in the *direction* of the pressure.

Where frames are cut at margin plates of inner bottoms or at water tight flats, efficient bracket plates of such dimensions as will permit of riveting to develop the strength of frame bars should be fitted. See Fig. 158 and 159. In wake of flats where bracket knees are objected to on account of the broken stowage created, or their interference with cabin arrangements, the framing may be continuous and smithed angle collars or pressed plate chocks fitted around them to ensure water tightness as in Fig. 150. For simplicity in forming collars, frame and reverse bar or channel section, the reverse bar, or flange, may be cut off and the frame bar doubled for a short distance above and below the flat as compensation as in Fig. 151.



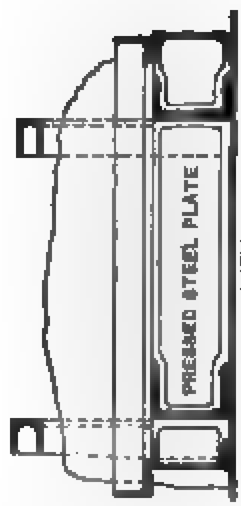


Fig. 150.

Where main frames are stopped at weather deck when the bridge house or superstructure requires a bar of smaller section, the connection between weather deck stringer and frame may be completed with a spirketting plate in lieu of the ordinary bracket knee where the latter would encroach on the berthing space, as shown at Figs. 152 and 153.

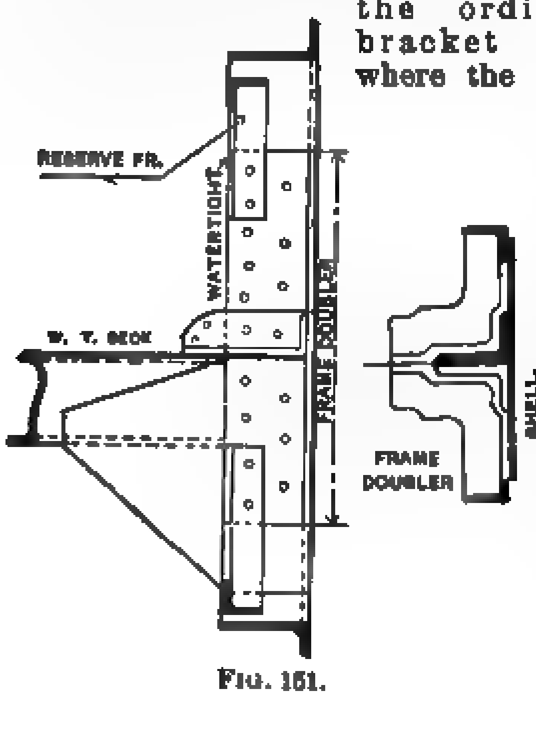


Fig. 151.

The inboard member of a ship's framing, called the reverse bar, whose functions are to provide a flange whereon to fasten the ceiling, or lining, and to give the necessary section modulus by adding area at a point subjected to corrosion and rough treatment, is commonly made of angle section or by the employment of channel bar for the framing. In steamers, however, under about 100 feet it will be found economical

besides being good construction to omit the reverse bar altogether and increase the sided flange of frame angle to give an equivalent

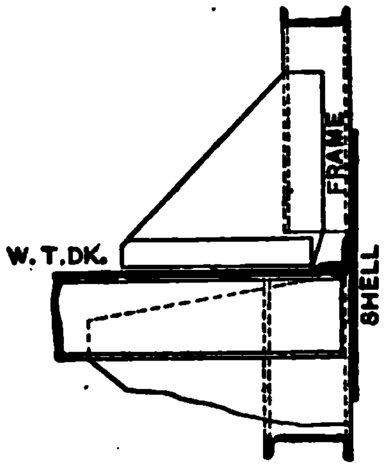


FIG. 152.

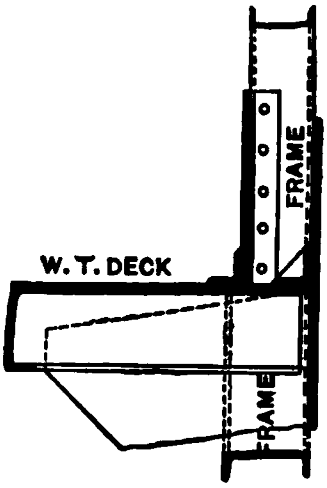


FIG. 153.

I. A saving in material, riveting and bending will thus be effected. In light vessels where weight must be cut down without encroaching on the strength, the maximum section modulus may be obtained for a given depth of web by employing two bars of such dimension of leg as will just give the requisite size of lap to take the proper riveting, as in Fig. 154.

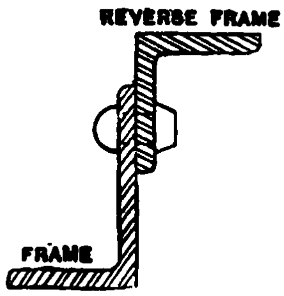


FIG. 154.

The practice in vogue for many years of placing the frame and reverse bars back to back has given place to that of fitting them bosom to bosom where deep framing is adopted, as by this method the beam knees can be fitted without linering in wake of reverse frames.

FLOORS.

The deep plates riveted to the bottom framing of ships and known as the floors, are placed there to resist the transverse stresses to which the bottom plating is subjected, due to the great water pressure externally applied, and the inside forces created by the weight of the structure and cargo.

Ordinarily in ships without an inner bottom these are of a size based upon the breadth and depth of the vessel and carried in a fair line up the bilge to a height equal to twice the centre line dimension as in Fig. 155. It will be seen that this contour at the bilge necessitates furnacing the tail ends to bend them to the required curve, a costly and therefore an objectionable feature. For this reason ordinary floors should be increased in their sided areas and carried straight across, striking the bilge at a point somewhat lower down than with the curved floor. This method permits of *the floor being* flanged across top in lieu of fitting a reverse bar,

although some of the classification bureau penalize flanging plates to the extent of adding one-twentieth to their thickness; this need not, however, be made unless where specifically required and for that reason cheaper, lighter, and equally efficient construction will be obtained.

In small freight steamers and barges a strong and inexpensive floor is obtained by using structural channel section thus eliminating the riveting to frame and reverse bar altogether.

Floors in inner bottoms are almost entirely fitted as deep solid plates in one piece from centre vertical keel to margin plate, lightened with large manholes to cut out superfluous material and provide access to the various compartments into which the bottom is sub-divided by the floors and intercostal girders. Deep floors should be lapped to the bottom frames just sufficient to take the riveting. In wake of watertight bulkheads or at ends of ballast

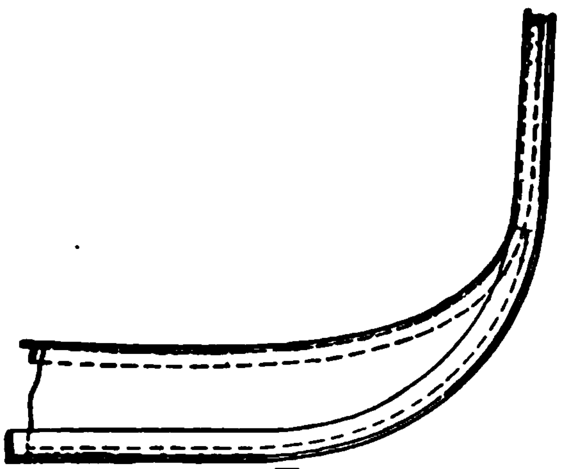


FIG. 155.

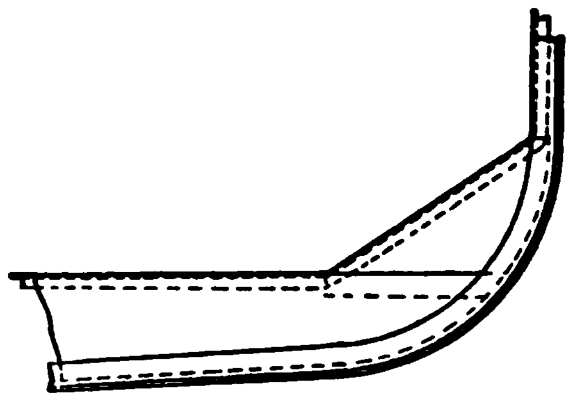


FIG. 156.

tanks where the floors are watertight, no holes whatever must be cut in them. The margin plate of inner bottom being continuous, is connected to the main frame by a large bracket plate or tail piece, and by double angles having a specified number of rivets and a gusset plate at top, or in the largest vessels a continuous stringer. The connection to the siding flange of main frame is by lap of sufficient width to take the riveting. See Figs. 157 and 158.

At the ends of the vessel where the waterline at top of floor would necessarily be comparatively narrow, increased depth must be given to provide compensatory area and also ensure sufficient width to clip the centre keelson to floors. In the fore peak this additional depth is required to resist buckling and panting, and generally to give local stiffening at a part subjected to unusual stresses. It is also necessary to increase the floors considerably in depth in after-peak, owing to the severe stresses encountered when the propeller "races" and the stern is in air.

INNER BOTTOM.

Double bottoms are fitted in vessels to enable them to safely make voyages "in ballast" without incurring heavy expenses by loading and discharging dry ballast. For this purpose the floors are plated over, forming an inner bottom enclosing with the ship's plating a pontoon in which to carry sea water as ballast, an expeditious, inexpensive and clean method of doing so. Two or three methods of fitting water bottoms are met with in practice, but as these have given way to the cellular system, it is unnecessary to describe them. This method consists in the subdivision of the space formed by the pontoon referred to, into a great number of small compartments or cells bounded by the floors in a fore and aft direction and transversely by intercostal girder plates, making these cells approximately two feet by four feet, respectively, by the depth of water bottom. The water passes freely between these cells as the floors and intercostals are pierced with access holes unless where mentioned hereafter. The cells are arranged in separate groups or compartments enclosed by the centre vertical girder, watertight floors and the margin plate, this larger subdivision being necessary for trimming and filling purposes, as otherwise a large surface of free water would be highly dangerous in certain conditions.

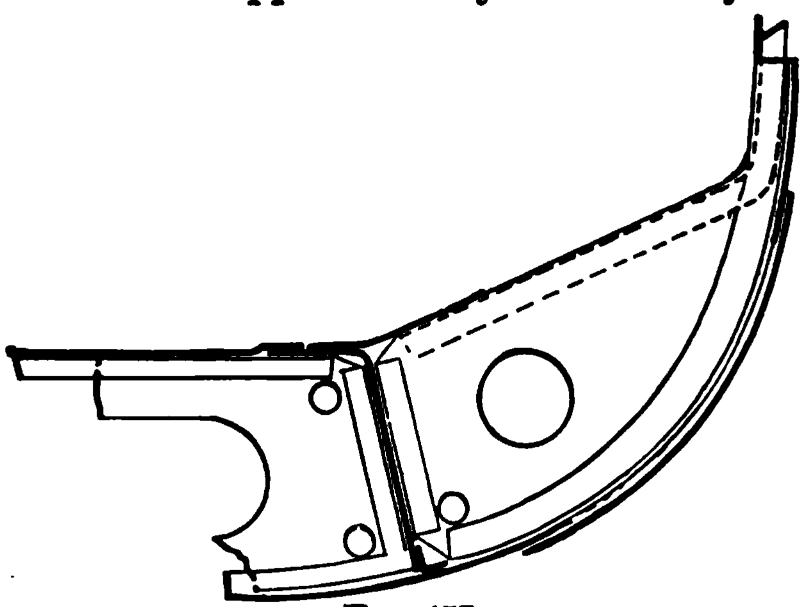


FIG. 157.

As mentioned, the centre vertical plate is continuous fore and aft, fitted usually watertight and connected top and bottom to inner plating and plate keel with suitable angle bars. No holes whatever should therefore be cut through vertical keel plate, and although it is not necessary to caulk it in way of ballast tanks, the riveting should be of watertight pitch. Of course where fresh water is carried this longitudinal girder must be properly caulked. At the ends of the vessel where fore and aft subdivision is unnecessary the centre plate may have access manholes as in the floors.

The butt connections are preferably formed with double butt straps, each of about two-thirds the thickness of plate. Through

butts should not be used here, as besides interfering with the passage of the fore and aft angles they only give single shear value to the riveted connection.

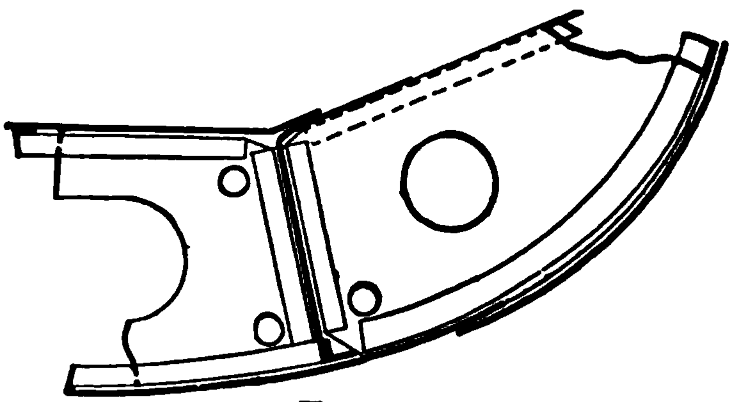


FIG. 158.

The outboard side of the inner bottom, or margin plate, is fitted to shell by means of a continuous angle bar, the main frames of the ship being cut for that purpose. At the top this plate is flanged in board to take the inner bottom plating as shown in Fig. 157. The butts of margin plate are covered with single strap fitted on the inside of tank.

This plate may also be fitted with advantage as shown in Fig. 158 devised by the author, which consists in flanging the plate outboard, a shape that the plate will take more naturally where there is curvature in a fore and aft direction. This outboard flange will also permit of machine riveting and connecting to the reverse flange or bar on the floor bracket, thus forming a continuous stringer; or, angle section may be substituted for the flange where facilities for bending are not obtainable.

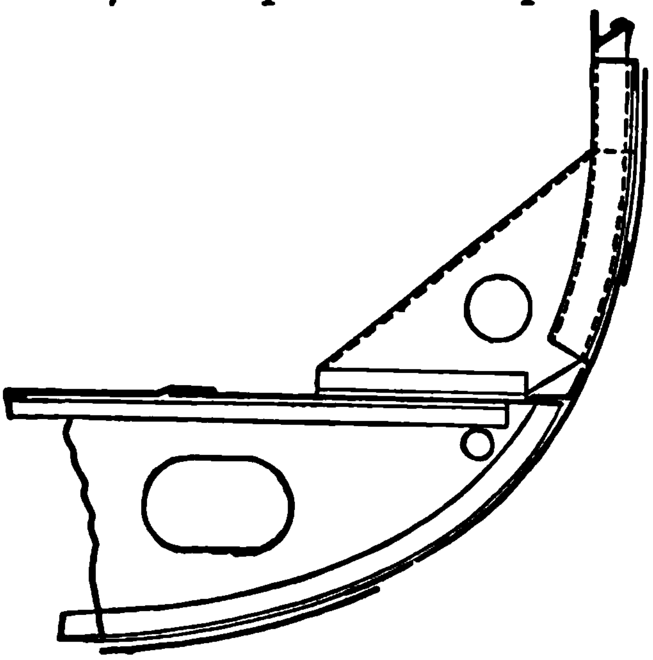


FIG. 159.

Another method of fitting the margin is illustrated by Fig. 159, where the top plating is carried right out to the shell and flanged upwards to take staggered riveting. Flanging is preferable to fitting an angle bar, as in the latter case difficulty would be experienced in putting in the rivets on the horizontal flange of the bar. It is, however, a cheap method of construction, its principal objection being the broken stowage caused by the brackets connecting frame to inner bottom.

The inner bottom plating will be of such thickness as the classification societies stipulate where the vessel is classed, when it will be found that increased scantling is required under engines and boilers, and of course the centre strake and margin plate will also be thicker than the rest of the plating, owing to the former being the rider plate member of the girder formed by the centre

vertical keel and keel plate, and the latter being an important factor in the longitudinal strength of the ship. For this reason when arranging the access manholes, these must always be kept clear of the centre strake. A good shift of butts must be arranged for the plating, and these shifted clear of the butts of shell, margin plate and longitudinals.

Where the strakes of inner bottom plating are arranged "in and out," the packing liners to outside strakes should be fitted short, the unfilled spaces acting as air holes.

The practice of fitting wood ceiling on tank tops is giving way to coating the plating, with tar or bitumastic cement, as this prevents the deterioration that goes on under the wood, besides adding to the stowage capacity. Where, however, wood ceiling is required, it must be laid on fore and aft bearers and screwed to same and *not* fastened through tank top. For this reason, *i.e.*, guarding against leakage the heels of the hold pillars are riveted to vertical flange of tee or angle lugs which are first riveted through inner bottom.

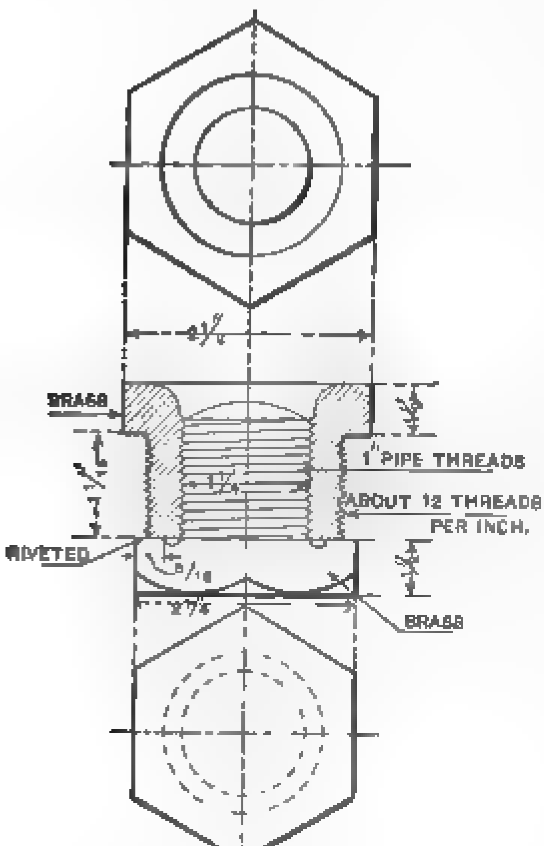


Fig. 160.

In arranging the manholes care should be exercised that they are located in accessible parts of holds and clear of cargo hatches. In holds of ordinary length one each side at each end about quarter the beam outboard will be sufficient, and in long holds an additional one about the middle of the length. In no case as previously pointed out should they go through the centre strake. The best location aft will of course be in tunnel alleyways, and in machinery spaces they should be fixed by the engineers. This arrangement will contribute to the best circulation of air when the covers are taken off for ventilating purposes. Ample room must be allowed for rim of manhole to clear landings, butts, longitudinal clips, etc.

The shell plating forming the bottom of tanks may be reduced

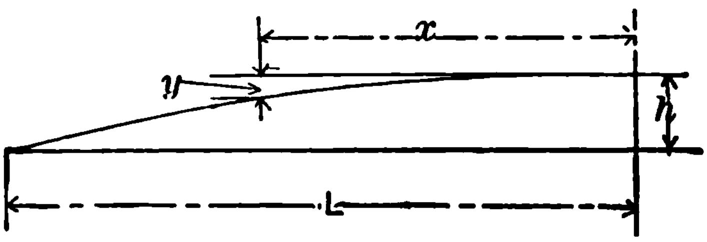
in thickness in consideration of the extra strength added by this construction, and the broad liners fitted to outside strakes in wake of watertight bulkheads may be replaced by narrow liners at watertight floors in tanks.

To drain the various compartments of the double bottom when the ship is in dry dock, screw plugs of composition are fitted in the garboard strake and a compensating plate riveted around the hole. A detail of such a fitting is shown by Fig. 160. It is usual to fit similar plugs in the trimming tanks at fore and after peaks.

BEAMS.

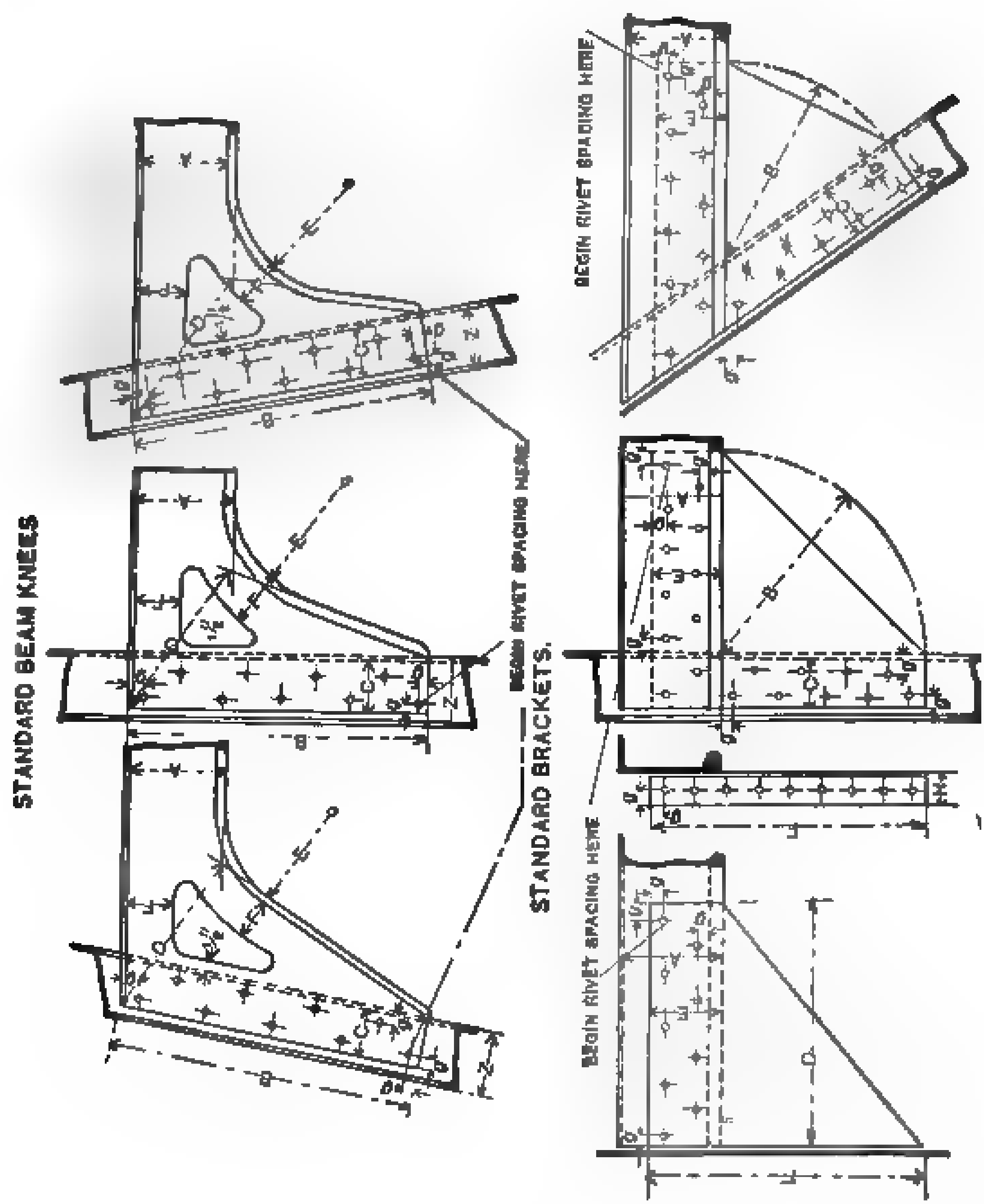
Beams are fitted at various levels, or decks, to tie the ship together and afford supports whereon to lay the decks to take cargoes. The strength of these will depend therefore on the load as well as the span or breadth of beam, as it will be seen that a weather deck beam need not be as strong as the one under it, and so on — each successive tier taking the accumulated load superimposed.

It is common practice to give all decks a round-up or camber, an expensive practice that is unnecessary unless on the weather deck, and only necessary there in a modified sense to obtain the statutory freeboard or to conform to classification requirements. It is a fallacy to imagine that strength is gained by cambering the beams thus supposedly constructing an arch, as you cannot have a compressed beam without abutments, which the sides of the ship are not. To meet the requirements mentioned above, the weather deck should have the standard camber of one-quarter inch to the foot of length, thus a beam 40 feet long will have a round-up at centre line of ten inches. This curve may be set off very quickly with the aid of a common slide rule by setting the courser to the required round-up on the first or top scale and to the half beam on the third scale, when the camber at any desired distance in board of ship's side may be found by moving the courser to the dimension required and reading off on top scale. The reading subtracted from the total camber will give the required round-up. This may also be figured as shown in Fig. 161. The beams are connected to the main



$$y = \frac{x^2}{L^2} h$$

FIG. 161.


STANDARD BEAM KNEES
STANDARD BRACKETS.
BEGIN RIVET SPACING HERE
BEGIN RIVET SPACING HERE
BEGIN RIVET SPACING HERE
BEGIN RIVET SPACING HERE

Figs. 162–167.

THICKNESS OF BRACKETS DEPENDS ON WEIGHT OF BEAM PER FOOT.

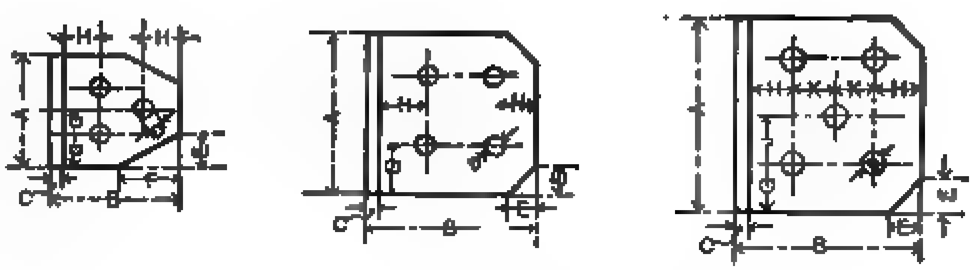
(See Figs. 162–164.)

A = Beam Depth.	B = 3 A.	C = Z Bar Depth Less One Inch.		D = 1.75 × A.	E = A + 1″.	F = ½ A	a = Assumed.	g = 1¾ × a.	Number of Rivets = Number of Inches in Depth of Beam.
A.	B.	C. 5″ Z Bar.	C. 6″ Z Bar.	D.	E.	F.	Rivet Dia. = a.	g.	Number of Rivets.
5″	15″	4″	5″	8¾″	6″	2½″	⅝″	1 1/16″	5″
6″	18″	4″	5″	10½″	7″	3″	¾″	1 ¼″	6″
7″	21″	4″	5″	12¼″	8″	3½″	¾″	1 ¼″	7″
8″	24″	4″	5″	14″	9″	4″	¾″	1 ¼″	8″
9″	27″	4″	5″	15¾″	10″	4½″	¾″	1 ¼″	9″
10″	30″	4″	5″	17½″	11″	5″	¾″	1 ¼″	10″

(See Figs. 165–167.)

A = Depth of Beam.	B = 2 A.	C = Z Bar Depth Less One Inch.		D = 2½ A.	E = .6A + 1″ (Take Nearest Quarter In.″)	F = B + E.	H is Assumed.	a is Assumed.	g 1¾ × a.	No. of Rivets in Each Lap or Flange = No. of In. in Depth of Beam.
A	B.	C. 5″ Z Bar.	C. 6″ Z Bar.	D.	E.	F.	H.	Rivet Dia. = a	g.	Number of Rivets.
5″	10″	4″	5″	12½″	4″	14″	2¼″	⅝″	1 1/16″	5″
6″	12″	4″	5″	15″	4½″	16½″	3″	¾″	1¼″	6″
7″	14″	4″	5″	17½″	5¼″	19¼″	3″	¾″	1¼″	7″
8″	16″	4″	5″	20″	5¾″	21¾″	3″	¾″	1¼″	8″
9″	18″	4″	5″	22½″	6½″	24½″	3″	¾″	1¼″	9″
10″	20″	4″	5″	25″	7″	27″	3″	¾″	1¼″	10′

TO FIT CARNEGIE'S 1897 PATTERNS.



I II III

Figs. 168 to 170.

Beam Depth	A.	B.	C.	D.	E.	F.	G.	H	J	K.	Style.
5″	3 ″	$3\frac{1}{2}$″	$\frac{5}{16}$″	$\frac{5}{8}$″	$\frac{7}{8}$″	$1\frac{3}{4}$″	$\frac{7}{8}$″	1 ″	$\frac{5}{8}$	. . .	I
6″	$3\frac{5}{8}$″	4 ″	$\frac{3}{8}$″	$\frac{3}{4}$″	$1\frac{1}{4}$″	2″	1 ″	$1\frac{1}{8}$″	$\frac{13}{16}$	.	I
7″	$4\frac{1}{4}$″	$4\frac{5}{8}$″	$\frac{3}{8}$″	$\frac{3}{4}$″	$\frac{3}{4}$″	. . .	$1\frac{1}{4}$″	$1\frac{1}{4}$″	. .	. . .	II
8″	$5\frac{1}{4}$″	$5\frac{1}{8}$″	$\frac{3}{8}$″	$\frac{3}{4}$″	$\frac{3}{4}$″	. . .	$1\frac{1}{4}$″	$1\frac{1}{4}$″	$1\frac{3}{8}$	$1\frac{1}{8}$	III
9″	6 ″	$5\frac{1}{8}$″	$\frac{3}{8}$″	$\frac{3}{4}$″	$\frac{3}{4}$″	. . .	$1\frac{1}{4}$″	$1\frac{1}{4}$″	$1\frac{3}{4}$	$1\frac{1}{8}$	III
10″	$6\frac{7}{8}$″	6 ″	$\frac{1}{2}$″	$\frac{7}{8}$″	$\frac{7}{8}$″	. .	$1\frac{7}{16}$″	$1\frac{7}{16}$″	2	$1\frac{5}{16}$	III

frames by welded knees or bracket-plates, the latter being much the cheaper and, where appearance is not important, the better method. The depth of these knees is commonly $2\frac{1}{2}$ times the depth of beam if of channel or bulb tee section, and three times the depth if angle bar be used. The thickness should be the same as the beam unless where welded knees are fitted, when it is good practice to increase the plate one-sixteenth to allow for loss in smithing. When dealing with beams conforming to Lloyd's Rules, it should be noted that the bracket knees are regulated in depth and thickness by the size of the *bulb plate* required by the table, irrespective of the dimensions of the substituted equivalent section of channel, bulb angle, or bulb tee. For example, if the rules require a built beam of bulb plate and angles, the former being $10\frac{1}{2}'' \times \frac{11}{20}''$, and it was decided to fit the equivalent channel bar of $11'' \times 3\frac{1}{2}'' \times \frac{14}{20}''$, then the bracket knee would be $26\frac{1}{4}'' \times \frac{11}{20}''$.

Standard beam knees as used in Navy practice are shown by Figs. 162 to 167. In arranging the riveting in plate knees, the required number is usually specified for classed vessels, and as these are invariably staggered, it is well to locate the first rivet hole as far outboard on the beam, and down on the frame, as practicable. Those in the corner may be treated as common to both arms in counting the number required.

Where unsheathed steel decks less than $\frac{8}{20}''$ thick are fitted, beams must be fitted on every frame, with stronger beams at ends of cargo hatchways. Where the thickness is $\frac{8}{20}$ or over, the beams may be fitted on alternate frames with half beams on every frame abreast of hatches. When this spacing is adopted, most societies require closer spacing of rivets through deck plating, viz., 5 diameters apart as against 7 to 8 diameters with the closer spaced beams, so that it is doubtful economy at a sacrifice of efficiency to space them on alternate frames.

In the machinery spaces of steamers it is necessary to fit beams of extra strength wherever these can be worked without interfering with the arrangement of engines and boilers. These through beams compensate for the loss in transverse strength through the severance of the regular deck beams at the large machinery openings, and serve to tie the ship together and prevent panting of the sides at a part where a considerable weight is permanently carried. In large steamers the machinery arrangement often permits of two adjoining through beams being tied together by cover plates, thus forming an exceptionally strong beam of box section. Where strong beams cannot be fitted in one piece, owing to interference with the shipping of parts, they should be efficiently bracketed to the casing coamings, care being taken that the connection develops the strength of beam. When practicable the pillars in machinery spaces should be fitted on these through beams.

The term **half beam** is applied to those deck beams which are severed in wake of hatch openings. Their inboard ends abut on the hatch side coaming plates, which are in consequence made thicker than the end ones, and the connection is commonly by a single angle clip (taking a specified number of rivets) if a continuous fore and aft angle is fitted at bottom of plate to support the beam ends, or the coaming plate is flanged under the beams for a like purpose. It will be thus seen that this rest will take a great deal of the shear off the rivet connection, besides adding to the strength of the girder formed by the coaming.

In wake of small deck openings the inboard beam end may be supported by a carling, or fore and after, of similar section to the beam, except where bulb tee is used with the *heel* of the carling abutting on beam end and connected to same with, preferably, double clips so as to get double shear value from the rivets.

ANGLE BEAM COLLAR

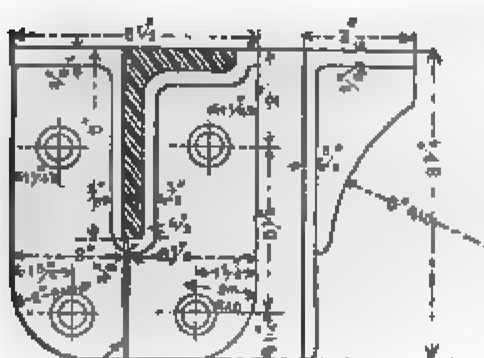


FIG. 171.

Where heavy local weights or deck machinery are secured, the beams in wake of same should be increased in section, and special pillaring or deck girders fitted. It is likewise necessary to increase the strength of the beams at the ends of hatchways by adding to their sectional area — but not to their depth if avoidable.

The beams supporting bridge or shade decks fitted over houses and extending to ship's side are frequently carried thwartship in one bar, the casings being scored out and watertight collars fitted, in preference to cutting the beams and fitting bracket plates. These collars are shown by Fig. 171, and may be smithed, stamped, or cast in steel or malleable cast iron.

HOLD PILLARS.

Support is given the beams on the various decks by stanchions. Various sections are employed for this purpose, as round bar, pipe, *I* section and columns built of channel or plate and angle bar. For vessels carrying general cargoes, the pipe section, being circular and light, is probably the best. The *I* section makes a very

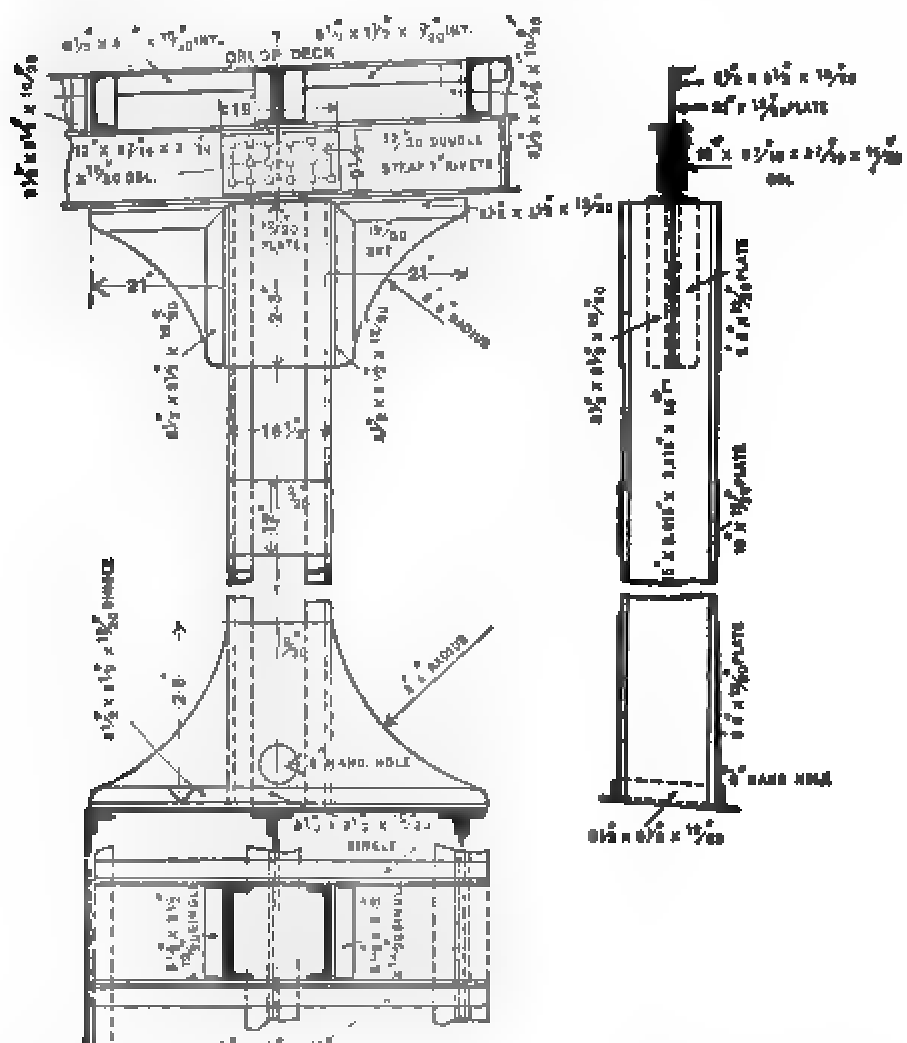
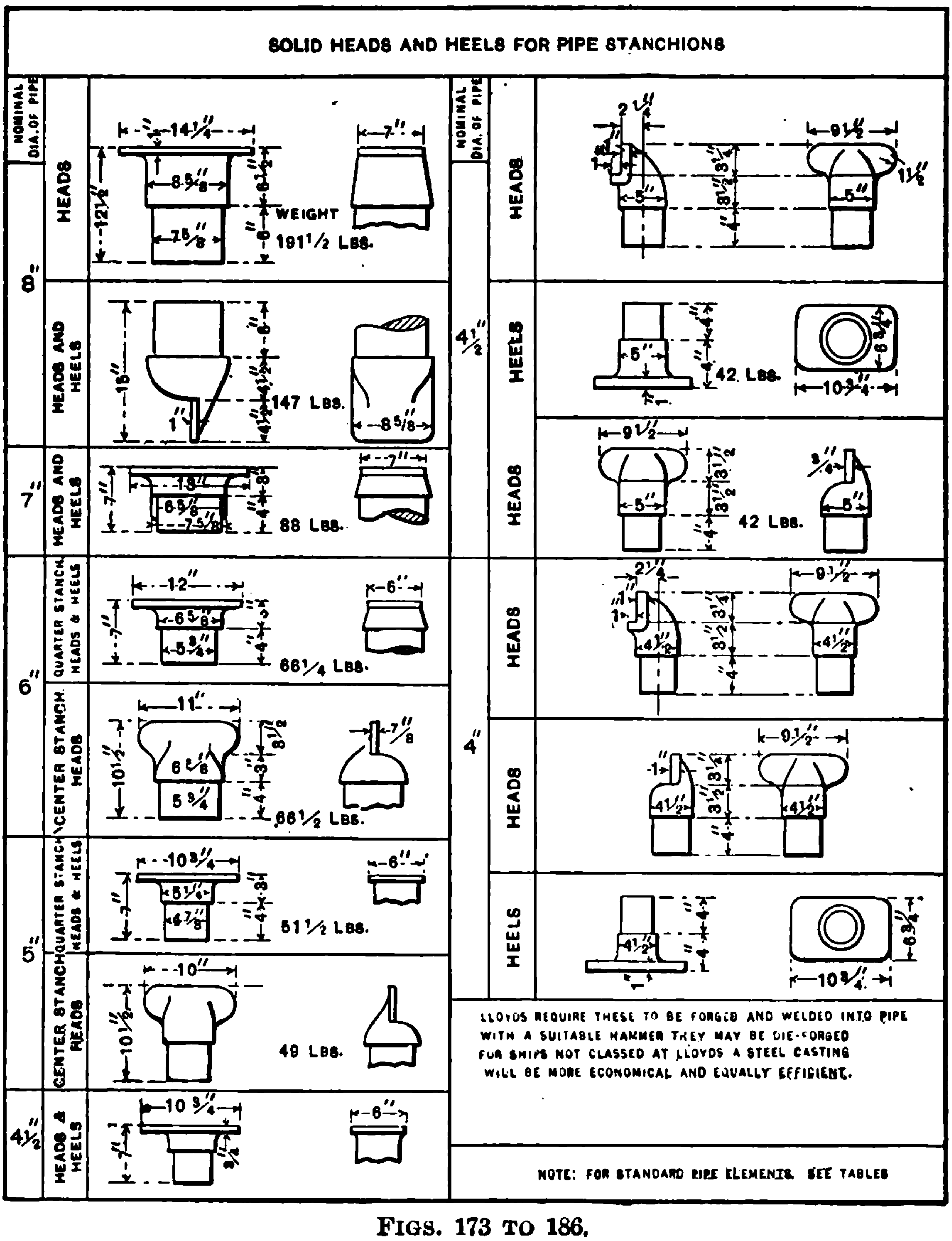


FIG. 172.

cheap and efficient column, as forged ends are done away with; and in vessels requiring large, clear, stowage spaces in holds, built columns should be fitted connected to strong deck girders. A very efficient type of built column is shown by Fig. 172, passed by Lloyd's Register for a span of 30 feet.

DETAILS OF HEADS AND HEELS FOR PIPE STANCHIONS.



FIGS. 173 TO 186.

Where pipe pillars are adopted, the accompanying diagram giving types of solid heads and feet will be found useful.

It will be obvious that the hold pillars must be stronger than those in the lower 'tween decks, the sizes being gradually reduced as we approach the upper works, owing to the reduction in the load which the successive tiers of pillars support.

As pillars are intended to take compressive stresses their relative strength with a given section is entirely in the end connections, and as the strongest of these is a fixed *closely* fitted *flat* end, this form should be adopted wherever possible. Where, however, it cannot be fitted, as on tank tops and with beams of section other than channel where no ridge bars are worked, care should be taken to fit closely the heads and heels on their supports, so that the load shall be taken on the column and not as a shearing stress on their fastenings, which should be relieved wherever possible of doing work.

In larger vessels, ridge bars of channel section are fitted under the beams to distribute the load taken by the pillars over all the beams and also to prevent the beams from *tripping*. In wake of hatchways where pillars are omitted or are fewer in number, intercostal plates are fitted between the beams and riveted to deck as compensation, thus forming a deck girder.

When hold pillars are stepped on inner bottom plating, a short piece of tee bar must first be riveted to tank top and caulked, and the heel of pillar afterwards riveted to the vertical stem of tee bar. A similar arrangement is adopted on expansion trunk tops of oil steamers for heels of gangway stanchions.

Where grain or other cargoes liable to shift are carried occasionally, the hold pillars may be staggered, the heads taking alternate flanges of the centre line ridge bar, thus providing an intervening space in which to fit the shifting boards.

HATCHES.

It will be seen that a serious loss in transverse strength is sustained by cutting the beams and decks to form hatchways, and it has been explained under the caption beams how this loss is compensated for in the deck framing and by increasing the sectional area of the side coaming plates.

Hatchways should be no larger than the demands of the particular trade call for, and the corners of these openings, at least on the strength deck, should be round. While it is cheaper to make them square, it will be found false economy. In addition to making them round on the strength deck the corners must be reenforced with doubling plates extending about 2 frame spaces each way and carried 18 inches or so around the corners. The coam-

ing angle bar must be welded; or a much better method is to run this bar to within nearly four feet of the corners around which another section is fitted having a much broader flange on deck; this will permit of staggering the rivets and so allow more space for sufficient riveting at the junction of this bar with the deck beam. No bosom piece need be fitted to cover the butt of the corner piece with the straight length of coaming angle, Fig. 187.

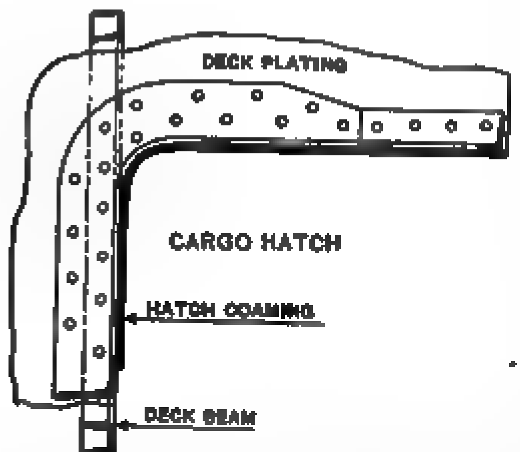


Fig. 187.

End coaming plates should have "pitch" in preference to camber, as they are more easily made and allow of better fitting the wood hatch covers. The height of coamings on weather deck must be from 2 feet to 2 feet 6 inches, and on other decks from 9 to 12 inches, care being taken that sufficient height is given to permit of the hatch battening cleats being fitted.

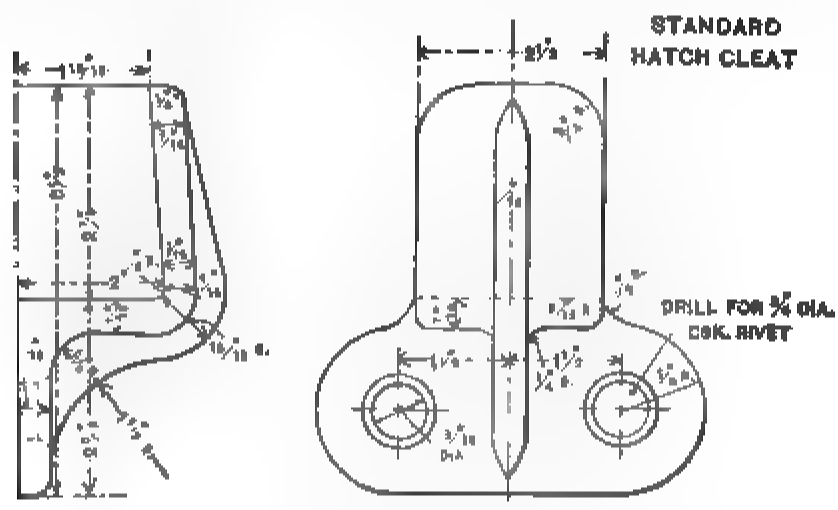


Fig. 188.

At butts of coaming plates the covering strap should be fitted on the outside and the rivets countersunk on both sides.

A typical battening cleat is shown by Fig 188 These may be either die forged or cast in steel and spaced not greater than 2 feet apart along the coaming plate, beginning about nine or ten

inches from the corners and sufficiently far down to give an easy fit for tarpaulin. The battening bar is of galvanized flat iron about $2\frac{1}{2} \times \frac{3}{8}''$, and the butts of same must not be at corners, the bar being bent round these to allow of fitting the canvas snugly. The tarpaulin is then secured by elm or oak wedges.

The ledges on top of coamings are mostly made of a special rolled section as shown, although where this is not obtainable a zee bar will answer equally well. These ledges should be mitred at the corners and of sufficient depth to house the hatch covers. In addition to the support afforded these by the ledge bar, fore and afters must be fitted, as well as bridle beams, to tie the hatchway, in number and scantling as required by the classification societies. The fore and afters are supported by rests riveted inside the end coamings and the hatch beams by socket slides on the sides. The only other mountings required on cargo hatches are a couple of lashing rings on each side fitted about four feet from the ends; these may be riveted on coaming plate or deck at discretion.

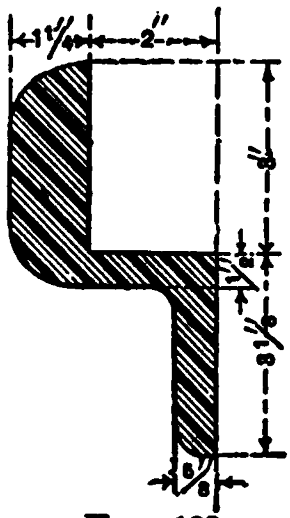


FIG. 189.

The wood covers should not exceed 24 inches in width, as otherwise they are too heavy, and are usually made of three pine deals, tie bolted with three $\frac{5}{8}''$ diam. blind bolts. On the right hand sides of top a lifting bar of iron through-fastened with two clench bolts is fitted, one at each end, and the wood drilled out about 5 inches in diameter to form a receptacle for the hand. These covers must have properly cut-in marks to facilitate replacing them.

WEB FRAMES.

Web, or, as they are sometimes called, belt, frames are commonly formed by fitting a plate from 15″ to 30″ deep to the ordinary ship's frame, and riveting an angle bar on the inner edge to stiffen and add to the resistance of the web. They may be also built with double channel frames with a covering plate on face — an advantageous method where increased room or stowage capacity is desired. Still another method is to fit frames and reverse bars of similar section of angles, webbing them as far apart as possible consistent with the requirements of the riveted overlap. These various methods of constructing web frames have all the same object in view, viz.: to give the equivalent compensatory transverse strength lost by omitting hold beams where large spaces are required for the stowage of certain freights or in machinery spaces where hold beams cannot be fitted. It will be seen that these beams really perform the function of struts tending to resist the

water pressures on the ship's sides and the hold cargo ; and for this reason, as well as those already given, should have no camber which it is conceivable tends to weaken them. If the hold beams then be left out, the necessary resistance may be given by increasing the section modulus of the side framing, and this is obtained by adding webbed frames at stated intervals along the sides, and by the more uniform subdivision in a vertical direction of the areas enclosed, by side stringers fitted intercostally between webs having a covering plate at their intersection, of diamond or half-diamond shape. The side stringers should stand squarely to the ship's frame, thereby insuring the maximum moment of resistance from the material used, as well as avoiding much bevelling of angle bars.

In addition to the foregoing, web frames are fitted wherever local losses in transverse strength take place, as at the sides of cargo doors and similar openings and over abrupt terminations of transverse strength, such as take place where a watertight bulkhead stops short of the strength deck. They are also necessary where exceptional local stresses of the nature indicated are applied.

KEELSONS.

The value of keelsons lies in their contribution to the longitudinal strength of the structure, and, where they are fitted in conjunction with intercostal plates having a shell connection, to the additional assistance given to the hull plating. In general practice it would seem that too much prominence is given to their strength as individual members rather than treating them as component members of the main structure, or ship itself viewed as a girder ; this is seen in the deep centre line keelsons fitted on top of ordinary floors; where continuous centre vertical plates are also fitted, the necessary efficiency and strength required locally may be obtained by thickening the lower parts of the member, as shown in Fig. 135, and at the same time increasing the moment of inertia of the ship's section as a whole about the neutral axis. Side stringers should be treated similarly, as illustrated by the adjoining sketch, the web instead of one flange of the channel being fitted against the reverse frame, permitting of a better connection thereto, at the same time distributing the resistance to fluid pressures over a greater surface and adding appreciably to the stowage capacity of the vessel.

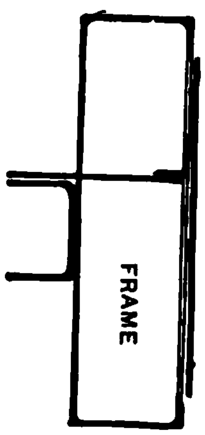


FIG. 190.

Where the plates forming side stringers are 18 inches (or over) wide, bracket plates must be fitted underneath to support and keep them standing to their work, except where webs are 8 feet apart. These brackets should be fitted midway between the web frames.

The practice of piercing watertight bulkheads with keelsons and stringers, and fitting angle collars around them to insure watertightness, should be discouraged, as a much stronger member is obtained by cutting the keelson or stringer and connecting same by bracket plates to the bulkhead. This method, besides, gives a more reliably watertight connection.

In arranging keelsons or bottom longitudinals, these where possible should be incorporated with engine foundation girders, or if this be impracticable, an efficient scarph should be made by continuing them past one another for about three frame spaces before terminating.

In ships of full form or where the flat of floor is carried well forward, additional intermediate longitudinals must be fitted locally, about half the depth of centre girder and connected to bottom plating to re-enforce the shell against "pounding."

Keelsons, longitudinals, or side stringers should never terminate abruptly, but wherever practicable should be ended on and bracketed to such supports as bulkheads, web frames, deep floors, etc. Care should also be taken to arrange the butts of these members clear of shell butts as well as "shifted" with one another. The rivets in the strap pieces should be developed to equal the strength of the member, and double shear value obtained in these connections wherever possible.

BULKHEADS.

The steel divisional partitions, built in ships, called "bulkheads," were primarily fitted to isolate the living and machinery spaces from the cargo holds proper, but were soon recognized as having a more important mission in subdividing the ship into watertight compartments besides adding considerably to transverse strength. So that in later years it has become a canon in ship design that a vessel's bulkheads shall be in number and arrangement sufficient to keep the ship afloat with any two compartments open to the sea. Watertight bulkheads must always be carried to the deck above the load waterline, and in the case of the collision or foremost one, to the weather deck, as the forepeak is the most liable to damage and flooding, producing a great alteration in trim. They may be plated either vertically or horizontally, and efficiently stiffened in accordance with the requirements of the classification societies' rules, observing in arranging stiffeners that these are placed on the reverse to the caulking side. In most yards the practice is to fit watertight bulkheads continuous from tank top to deck level, but it is considered better construction to fit the steel decks continuous and the bulkheads intercostally.

As these steel partitions are connected to the ship's side by single

or double angle frames with closely spaced rivets in the sided flange, it will be seen that this line of perforations around the shell is a source of weakness. To compensate as far as possible for this, it is necessary to fit doubling plates, or "liners," where practicable, *i.e.*, in wake of the outside strakes of shell plating. These liners may extend from frame to frame, or, as is more often done, for a sufficient distance on each side of bulkhead, to take another row of rivets, observing that these holes need only be spaced for watertight riveting on the caulking side of bulkhead.

Owing to the water pressures being greatest on the bottom, the plating is graded in thickness towards the top, and of course the section of stiffening bars is likewise reduced. The lower stiffeners require bracketing to tank top; and in detailing the riveting of these brackets, it should be borne in mind that one arm takes tensile and the other shearing stresses. Watertight spacing is required for all riveting except stiffeners and their connections.

Where web frames or deep framing is substituted for hold beams, additional horizontal stiffening must be given the bulkheads at the level at which the lower deck would ordinarily support the bulkhead, and in addition a deep centre line web fitted.

Generally it will be found convenient to arrange for the caulking side of bulkhead to be that side on which the open bevel frame shows, that is, the after side in fore-body bulkheads, and the forward side in after-body bulkheads. There are exceptions, however, to this rule which will suggest themselves in considering deep tank and peak water tests. As, of course, it is only necessary to caulk one side of the bulkhead, the stiffening bars should be arranged on the opposite side.

Where stiffening bars, especially angles, are exposed in cargo holds or between deck spaces, their sharp edges must be protected by fitting wood chafing pieces projecting about an inch and a half beyond the toe of bar and bolted to the stiffening flange.

SHELL PLATING.

The skin of the ship when constructed of steel is almost invariably arranged in fore and aft strakes "in" and "out" alternately. For the reasons given when treating on keels, the flat plate should be fitted as an "in" strake, so also should the sheerstrake except in large steamers where a doubling is required. For fitting and shoring purposes, it is an advantage to fit the bilge strake "inside," as well as strakes adjoining longitudinals.

In laying off the widths of strake on the midship section, it will facilitate interchangeability of individual plates if all strakes of the same thickness are made similar in width. It will also be found advantageous to work the bilge strake narrower than the

others where an odd size is unavoidable. In moderate sized vessels the outside strakes are usually from 40 to 46 inches wide, and the inside ones 48 to 54 inches, but in the largest ships it will be good practice to increase these widths, although by so doing increased riveting of butts will be necessary. On the other hand, when dealing with small vessels or light scantling craft narrower plates should be worked.

The widths having been arranged satisfactorily on the midship section, should now be transferred to a body plan and run in to the

PLATE LINES

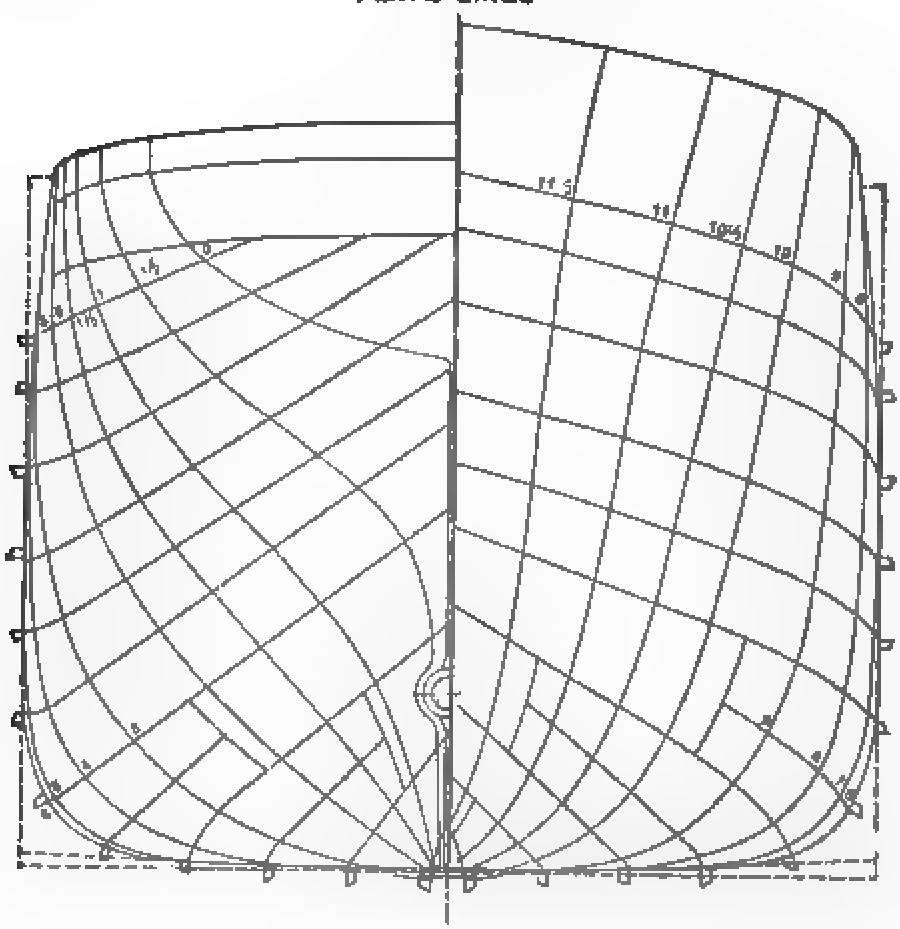


Fig. 191.

eye as shown by Fig 191, observing that in the fore body above the waterline the widths are kept parallel, which necessitates working stealers in the under-water body at the fore end. Running these plate widths parallel gives a straight, sharp appearance to the sight edges, a very important point when lining off a very full ship, as otherwise the rounding up lines developed would

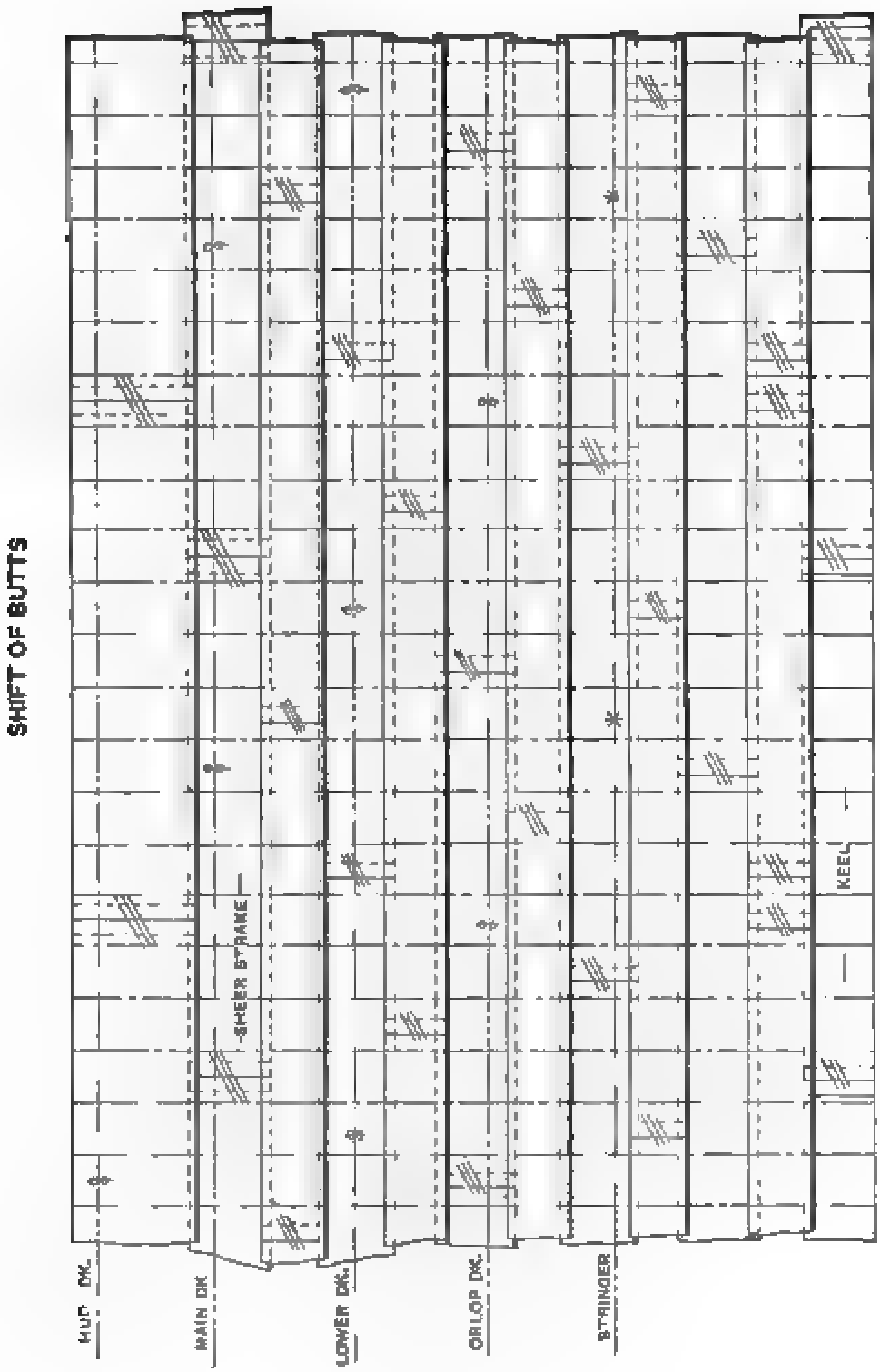

SHIFT OF BUTTS
SHEER STRAKE
KEEL
HUR. DK.
MAIN DK.
LOWER DK.
ORLOP DK.
STRINGER

FIG. 192.

accentuate and exaggerate the bluff lines. In addition it enables us to work the narrow plates where the form is most difficult to work. In the after body different conditions exist, the most important plate line being that which ends at the oxter, so that it is only necessary to divide the space intervening between that point and the sheer strake into the number of strakes obtaining amidships. The ending of a plate-line in the oxter is advisable to obtain all the furnacing and difficult work on one plate only.

Having run the plate lines on body plan to fulfil the foregoing conditions, these may then be taken off and faired up on the model.

If it be found that one of the landings crosses the continuous angle of tank margin plate or watertight flat, the line must be stopped abruptly near the point of intersection and "jogged" across for a sufficient distance before resuming its flight.

Before any butts whatever are laid off, either for stringers or shell plating, a small diagram should be drawn giving the general scheme for the shift of butts which will enable the various structural plans to proceed simultaneously and independently. No butts on adjacent strakes should be placed nearer one another than two frame spaces, or one frame space where a strake intervenes. The ideal shift of butts, however, is that which shall have not more than one shell butt in any one frame space from keel to gunwale. After the shell plate butts have been arranged, those of stringers, longitudinals, keelsons, etc., may be set off in the best positions in relation to shell. Such plates as require furnacing should be arranged as short as possible, the most difficult of these being the "hip" plate on the quarters, oxter plate, boss plate, the "breeches" plate taking stern frame and plate keel, and the similar plate of spoon form forward adjoining the stem. In some forms of vessels it is also advisable to make a short plate of those having double set at fore and after ends of bilge where the latter begins to curve into the entrance and run of vessel respectively.

A scheme of butts such as the one suggested is shown by the accompanying diagram, Fig. 192.

The "landings," as the edge overlaps of the in and out strakes of plating are called, should be of the width necessary to take the required size of rivets, which must be spaced for watertight work, *i.e.*, 4 to 4½ diameters apart, observing that where double riveting is employed a single rivet only should be inserted at the closing, or caulking edge, in wake of all frames. In yacht construction where a perfectly smooth topside is desired, the plating is often arranged edge-butt fashion with an inside continuous seam-strap — a more expensive and less efficient method than the other, and adopted solely for appearance.

In small moderate sized vessels the garboard and sheerstrake

landings only are double riveted, but in large vessels all of the landings should be provided with two rows; and where exceptional local loads are carried, as in deep tanks, or in vessels above 480 feet in length, "the landing edges should be treble riveted for one fourth of the vessel's length in the fore and after bodies for a depth of one third the vessel's depth." Vessels slightly under this dimension may have double riveted landings with an additional rivet added in each frame space within the zone mentioned. Where a change is made from a treble to a double, or from double to single riveted landings, the taper must of course be made on the inside or hidden edge, and should extend over a frame space.

Individual plates of strakes should be fitted in as long lengths as the steel makers' limits allow, or the facilities of the particular yard permit, consistent always with good practice. The old method of fitting these with edge-butts having an inside covering strap has been almost entirely superseded by overlapping the plates, a stronger and more enduring method. There are some strakes and special cases, however, where it is still advisable to retain the edge-butt connection, as in flat plate keels, sheerstrakes and the strake in wake of bilge keels, as by this means we get a closer fitting for keel angles, stringer bars and mouldings and bilge bars, eliminating unsightly work, trouble and the expense of fitting liners.

Where the overlapped landing of an outside strake crosses the buttlap of the adjacent inside strake, it will readily be seen that a small wedge-shaped space is formed. To close this up and so obtain the necessary watertightness, it is customary to scarph the corner of the overlap, allowing it to be drawn home. In wake of the outside strake overlaps, where they adjoin the inside landing edge, planing is impracticable, and, as a similar wedge-shaped aperture interferes here also with watertightness, this is secured by fitting a tapered liner long enough to take three rivets. A similar tapering away of the outside landing edge is performed where the strakes end on stem and stern post, thus giving the appearance of one flush thickness at these parts.

Wherever the shell plating is cut to form cargo doors, coal chutes, sea connections, sidelights, etc., compensation must be given for the loss in strength sustained. More especially is this imperative where these openings occur amidships through the sheerstrake, as it is then obvious that the strength is reduced to a maximum, being at the extreme fibres and where the greatest bending moments are produced. To avoid abrupt discontinuities as much as possible, the corners of all such holes where not circular should have a bold radius, and in addition kept well clear of butts. In addition, doubling plates must be fitted, observing that these should be *over* the openings and encircling the upper stresses *acting on the* upper corners, as the stresses acting on the upper

works which need resisting most are tensile. Where sidelights are cut through the sheerstrake, compensation may be given by slightly increasing this strake in thickness or by fitting compensating angle-bars over the openings.

The shell plating, as will be seen, really forms, in conjunction with the strength deck, the sides and bottom and top members respectively of the ship viewed as a box girder. For this reason the parts taking the greatest stresses are those at the greatest distance from the neutral axis; and as a ship is not always in the upright position in a seaway, it will be evident that these parts are the sheerstrake, bottom and bilges. Thus the classification societies stipulate for thicker plating at these parts. As the greatest bending moments are exerted amidships, diminishing towards the ends, they require that the maximum thickness shall be retained for a quarter of the vessel's length before and abaft the dead flat frame. There are, however, certain localities beyond these limits where the midship thickness must be maintained if not increased where abnormal local conditions demand it. Conditions such as are referred to exist at the ends of plates adjoining the stern frame, where, besides making the connection to a heavy forging requiring very large rivets, excessive vibration of a fatiguing nature is encountered; and at the bossed plating, oxter and hip plates requiring furnacing and much consequent hammering, where a serious reduction in the original thickness takes place in addition to the distress to the plate consequent on the treatment to which it is subjected. Also doubling or increased thickness must be provided at abrupt breaks in the longitudinal strength, as at ends of poops or bridge deck superstructures, in wake of hawse pipes, etc., and at other points which present themselves and will be evident to the observant.

DETAILS. FITTINGS.

Only next in importance to the structural details are the deck and other fittings, on which the convenient and safe handling of the ship depends. These in many cases do not receive that consideration which their importance merits. Instead of being calculated on a rational basis and designed accordingly, ship fittings are too often left to the guesswork of the technically untrained, with the result that we often find in these fittings a wide variation in the scantlings employed for a given duty even amongst like fittings on the same ship where different sizes are used.

With the object, then, of proportioning these fittings from a rational unit and standardizing them, the following tables of fitting details have been prepared or collected. The basis on which the unit is founded is in many cases given, enabling the expe-

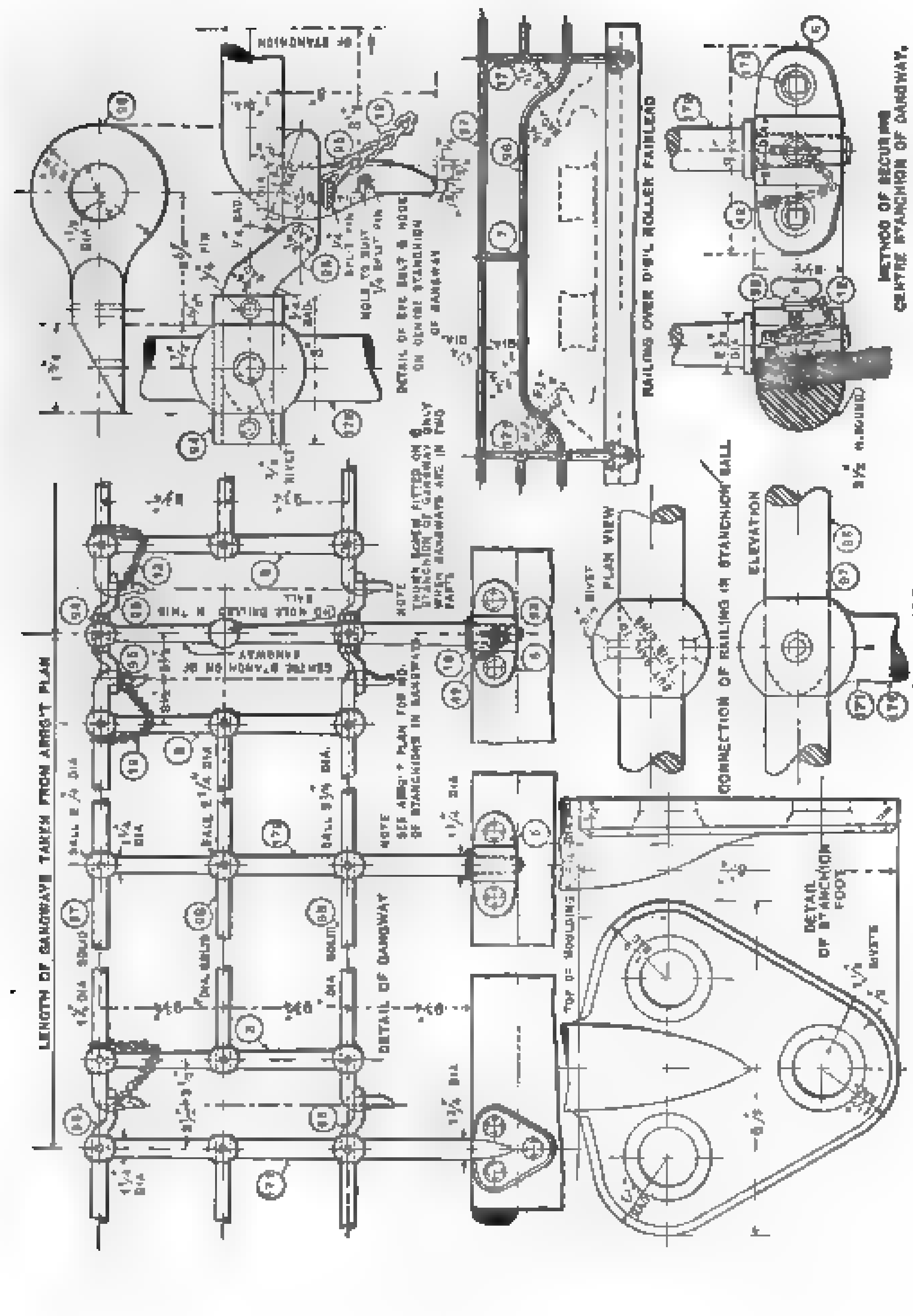


FIG. 193.

rienced to determine for themselves what variation may safely be made where fittings are being designed for special work.

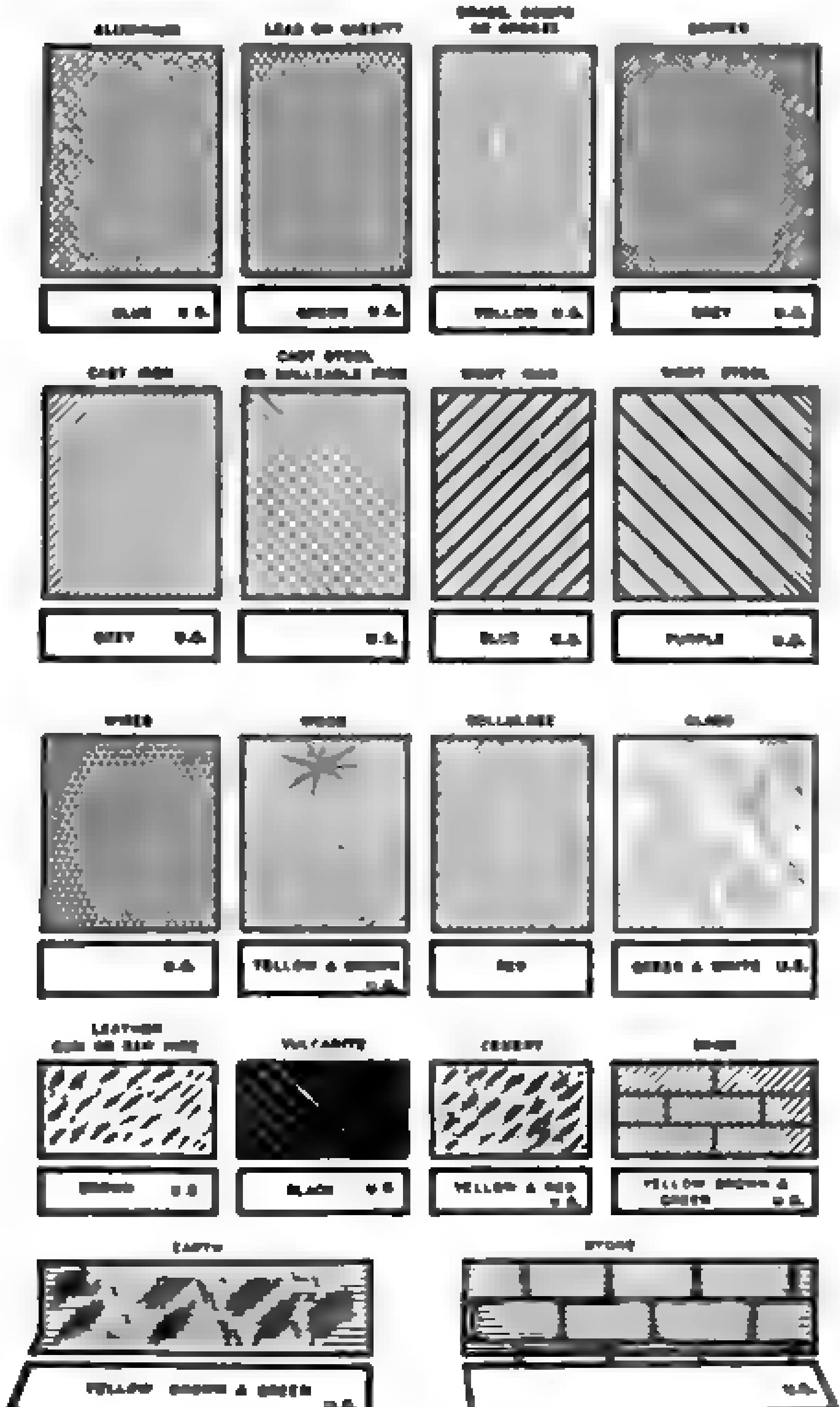
In the preparation of details it will be found to contribute much to their elucidation if a "fitting list" or "bill of material" be added alongside the detail delineated, and each and every part of the fitting given a special "piece number." The number plan of the general arrangement on which the details are assembled should likewise be given, and of course these piece numbers indicated on this assembly drawing for identification. The piece numbers will also prove helpful as reference numbers in discussions or correspondence relating to the particular fitting.

The adjoining specimen plate, with its accompanying bill of material, has been prepared to illustrate the method advocated.

BILL OF MATERIAL FOR ONE BOAT.

No. Required.	Piece No.	Pattern or Die No.	Name.	Material.	Weight in Lbs.	Drawing No.
44 ft.	6	Pat. 79	Socket	M. C. I.	(To be filled in by Foremen.)	86–370
12	7	Die 670	Rail stanchion	W. I.		"
70	8	" 673	" "	W. I.		"
26 yd.	12	. . . .	Safety chain	Red metal		"
12	23	Pat. 103	Thumb screw	Comp. N.		"
43	42	. . . .	Screw eye	Brass		"
56	93	Die 685	Eye bolt	W. I.		"
28	94	. . . .	1″ W. I. gas pipe sleeve,	W. I.		"
58	95	. . . .	$\frac{1}{4}$″ split pin	W. I. (galv'd.)		"
74	96	Die 691	Eye in end of rail . . .	W. I.		"
810 ft.	97	. . . .	$1\frac{1}{4}$″ rod (top rail) . . .	W. I.		"
2,365 "	98	. . . .	1″ rod (middle and lower)	W. I.		"
88	170	. . . .	$1\frac{1}{8}$″ tap bolt	W. I.		"
86	171	Die 675	Rail stanchion	W. I.		"
44	172	" 676	" "	W. I.		"

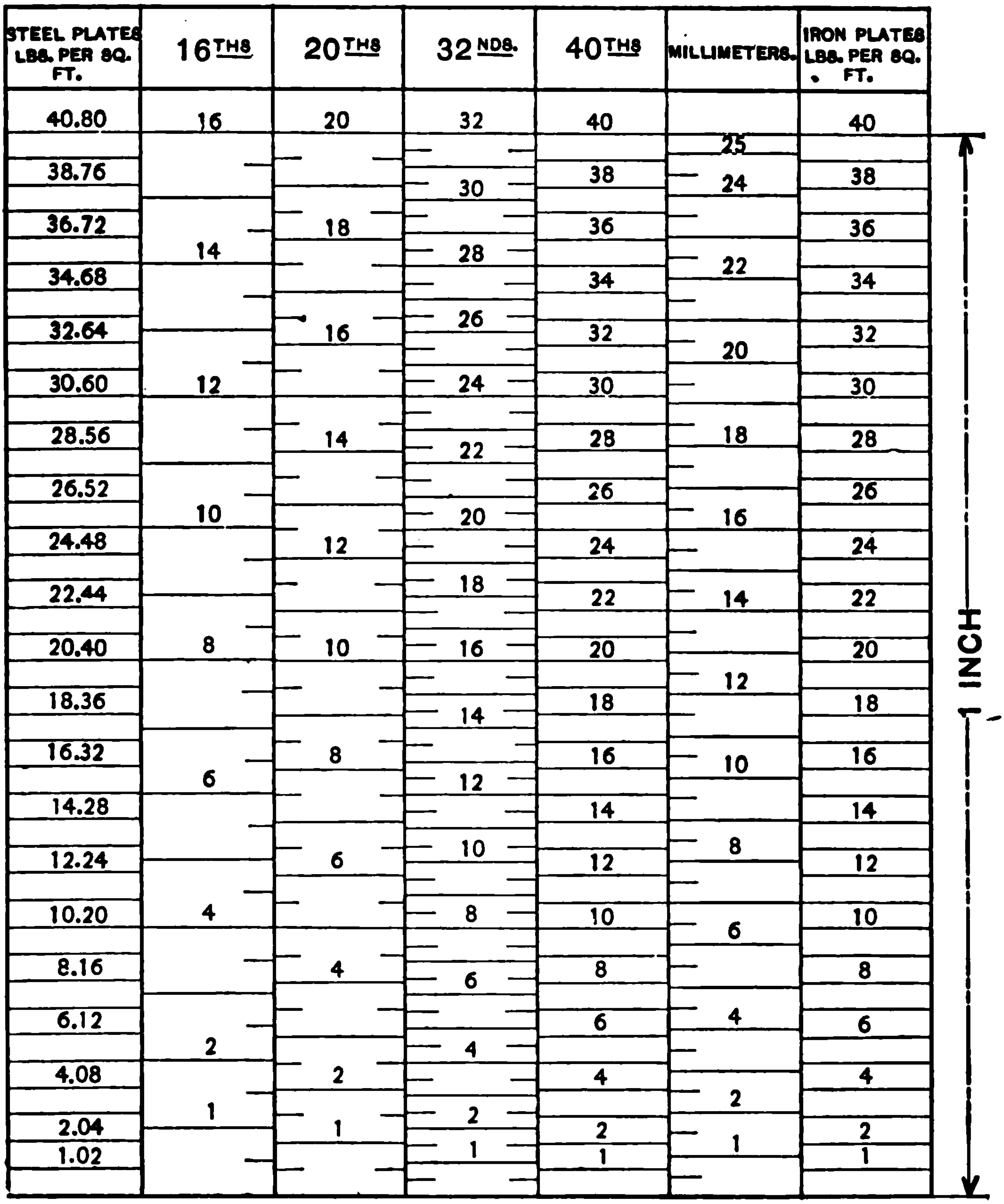
STANDARD HATCHING FOR VARIOUS MATERIALS.



FIGS. 194–211.

GRAPHIC DIVISION OF ONE INCH.

1 INCH DIVIDED INTO



BALDT ANCHOR.

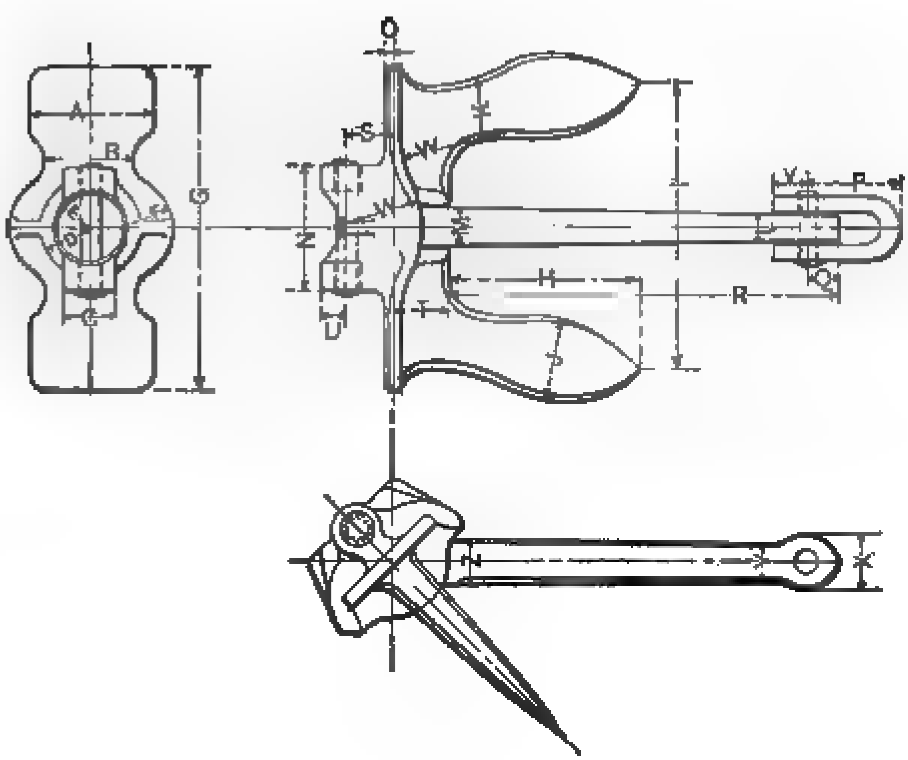


FIG. 212.

DIMENSIONS OF BALDT STOCKLESS ANCHORS.

(Cast Steel.)

WEIGHT IN POUNDS.

LBS.	5,600	5,400	4,760	2,940	1,820	1,680	840
	"	"	"	"	"	"	"
A	23	23	21 3/4	20	17 7/8	16 1/2	14
B	16	16	15 1/2	14	10 1/4	10 1/4	9
C	10	10	10	9 1/2	6	6	4 3/4
D	9 1/4	9 1/2	8 3/8	8 1/2	7 1/8	7 1/8	5 1/4
E	7 3/4	7 3/8	6 7/8	6 5/8	4 15/16	4 15/16	3 7/16
F	9	9	9	9	8	8	5 11/16
G	60	60	56 1/4	50 1/2	44 1/2	41	33 1/4
H	35	35	33 1/2	30 1/4	25 1/8	25 1/8	20
I	53	53	51 3/4	45 3/4	37 3/4	37 3/4	30 3/8
J	16 5/8	16 5/8	15 1/4	13 1/2	10 3/4	10 3/4	8 3/8
K	12	12	11 1/4	8 3/4	7	7	6
L	5 3/4	5 1/4	5 1/2	5	3 3/4	3 3/4	3
M	7	7	6 3/4	6	4 1/2	4 1/2	3 7/16
N	23 1/8	23 1/8	21 1/4	20	15 1/2	15 1/2	12 1/4
O	2 3/4	2 3/4	3	2 1/2	2 1/2	1 3/4	1 5/8
P	16 3/4	16 3/4	15 7/8	15 1/4	11 1/2	11 1/2	9 1/4
Q	6	6	5 1/2	5	4 1/8	4 1/8	3
R	72	72	72	66	54	54	40
S	8 3/4	8 3/4	8 1/4	7 5/8	6 1/4	6 1/4	4 1/16
T	10	10	9 3/8	8 3/4	6 5/8	6 5/8	5 1/8
U	5	5	5	4 3/4	3	3	2 3/8
V	6	6	5 3/8	4 1/4	3 7/8	3 7/8	3
W	18	18	17	16	12	12	9 1/8
X	9	9	8 3/4	8	6 1/4	6 1/4	5
Y	6 1/4	6 1/4	7 1/4	5 3/4	5 1/4	5 1/4	3 1/2
[illegible]	8	8	7 1/2	7	5 1/2	5 1/4	4 3/8
CWT.	50	48 1/4	42 1/2	26 1/4	16 1/4	15	7 1/2

HALL ANCHOR.

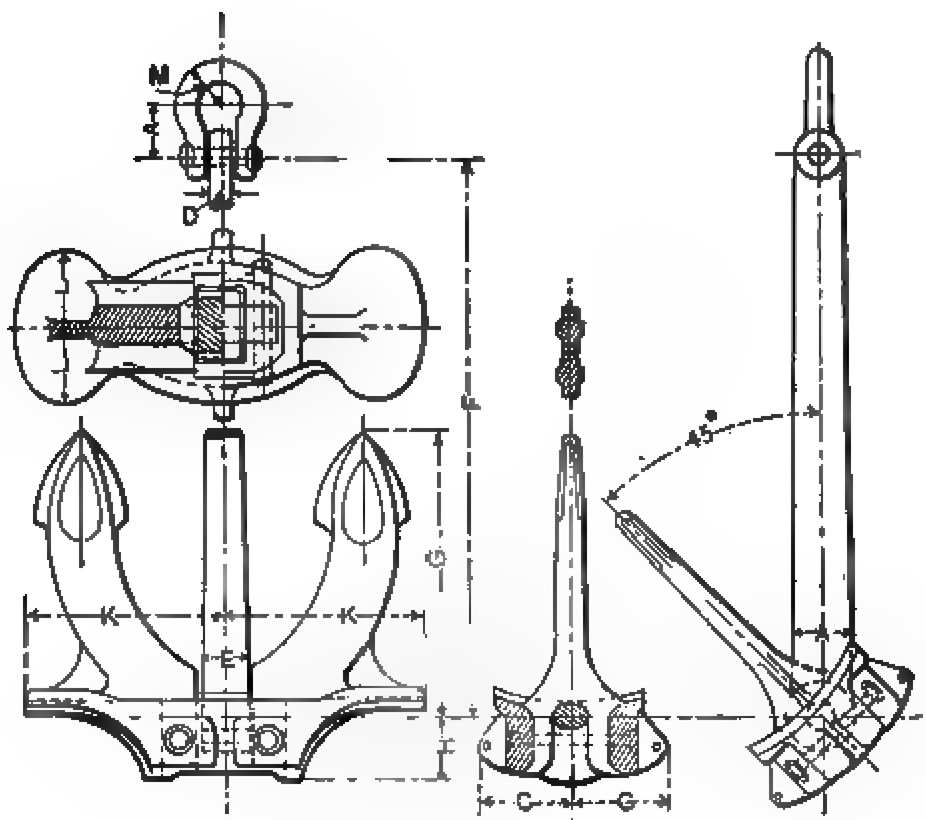


FIG. 213.

DIMENSIONS OF HALL ANCHORS.

Weight of Anchor (W) in Lbs.	$A = .558 \sqrt[3]{W}$.	$B = .622\ A$.	$C = 1.589\ A$.	$D = .412\ A$.	$E = .857\ A$.	$F = 9.616\ A$.	$G = 4.808\ A$.	$H = 1.177\ A$.	$I = 2.401\ A$.	$K = 3.412\ A$.	$L = 1.323\ A$.	$M = .72\ A$.
165	3.07	1.93	4.92	1.26	2.64	29.53	14.76	3.62	7.36	10.47	4.06	2.20
220	3.39	2.09	5.43	1.38	2.91	32.52	16.26	3.98	8.11	11.54	4.49	2.44
330	3.86	2.36	6.18	1.57	3.31	37.05	18.54	4.53	9.25	13.15	5.12	2.80
440	4.25	2.64	6.81	1.73	3.66	40.00	20.43	5.00	10.20	14.49	5.63	3.07
550	4.61	2.87	7.36	1.89	3.94	40.28	22.13	5.43	11.06	15.71	6.10	3.31
660	4.88	3.03	7.80	2.00	4.17	46.90	23.47	5.75	11.73	16.65	6.46	3.50
880	5.35	3.35	8.54	2.20	4.61	51.42	25.71	6.30	12.67	18.27	7.09	3.86
1,100	5.70	3.58	9.25	2.40	4.96	55.63	27.80	6.81	13.90	19.72	7.68	4.17
1,320	6.14	3.82	9.80	2.52	5.28	59.02	29.40	7.24	14.76	20.95	8.11	4.41
1,540	6.46	4.02	10.32	2.68	5.55	62.02	30.91	7.60	15.51	22.[illegible]	8.54	4.65
1,765	6.77	4.21	10.83	2.80	5.79	65.04	32.52	7.96	16.26	23.11	8.98	4.88
1,985	7.05	4.37	11.26	2.91	6.02	67.68	33.86	8.27	16.93	24.06	9.33	5.12
2,200	7.28	4.53	11.65	2.99	6.26	69.96	35.00	8.58	17.48	24.88	9.65	5.28
2,700	7.83	4.88	12.56	3.23	6.73	75.28	37.64	9.21	18.82	26.73	10.35	5.67
3,310	8.35	5.20	13.35	3.43	7.17	80.16	40.42	9.80	20.04	28.54	11.02	6.02
3,860	8.78	5.47	14.06	3.62	7.52	84.33	42.50	10.35	21.06	29.96	11.61	6.34
4,410	9.17	5.71	14.69	3.78	7.[illegible]	88.47	44.39	10.79	22.00	31.30	12.13	6.65
4,960	9.63	5.95	15.24	3.94	8.15	91.54	46.09	11.22	22.87	32.52	12.60	6.89
5,510	9.88	6.14	15.79	4.06	8.46	94.92	47.82	11.61	23.74	33.70	13.07	7.18
6,610	10.51	6.54	16.81	4.33	9.02	100.99	50.81	12.36	25.24	35.87	13.90	7.60
7,720	11.06	6.89	17.68	4.57	9.49	106.26	53.49	13.03	26.58	37.76	14.65	7.96
8,820	11.58	7.20	18.50	4.76	9.92	111.30	56.03	13.62	27.80	39.83	15.32	8.35
9,920	12.00	7.48	19.21	4.96	10.28	115.36	58.02	14.13	28.82	41.32	15.91	8.66
11,020	12.44	7.76	19.88	5.12	10.67	120.28	60.06	14.65	29.88	42.78	16.46	8.98
13,230	13.23	8.23	21.14	5.43	11.34	127.09	63.88	15.55	31.77	45.46	17.52	[illegible]

ADMIRAL ANCHOR.

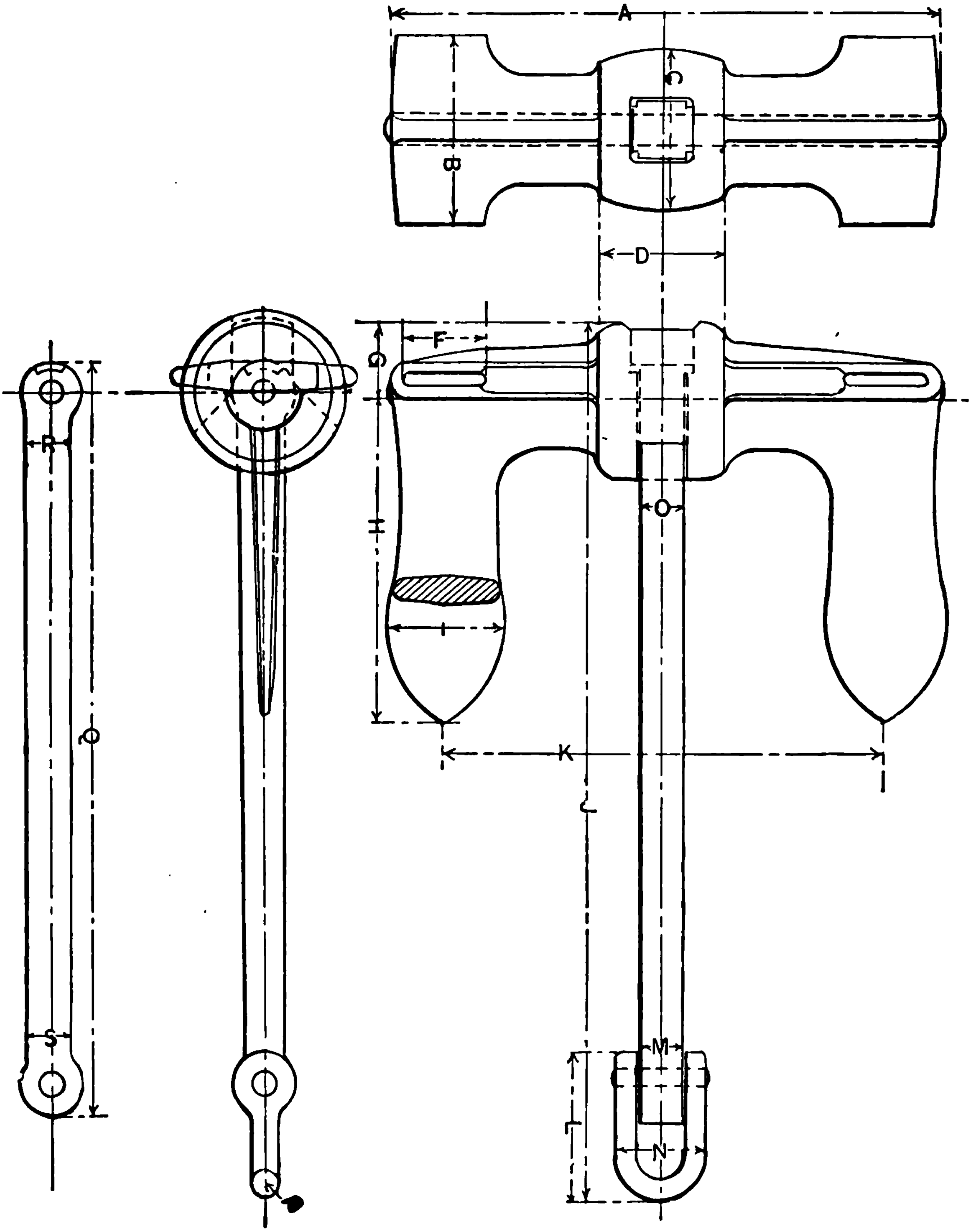


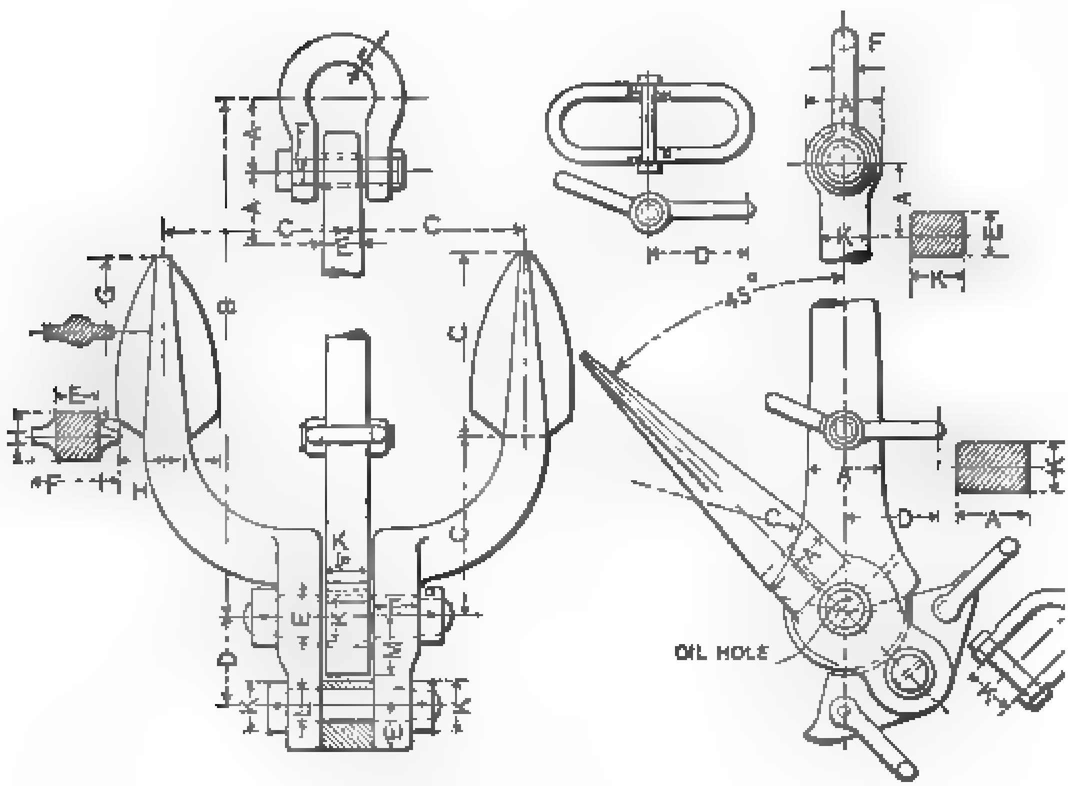
FIG. 214.

ADMIRAL ANCHOR.

	9,240	7,840	3,080	1,340	6,104	5,180	1,792	910
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
A	8 0	5 9	4 6	3 6½	5 5	4 11	3 6½	3 1
B	2 9	2 7	1 11	1 8	2 5	2 1½	1 8	1 6
C	2 4	2 2	1 6	1 3	2 0	1 8½	1 3	1 1
D	1 10	1 8	1 2½	1 1½	1 5½	1 4	1 1½	10¼
F	1 4	1 3	0 10¾	0 8½	1 1	0 11½	0 8½	0 7½
G	1 2	1 1	0 9	0 7½	1 0	0 10¼	0 7½	0 6½
H	4 8	4 4	3 2¼	2 6¼	3 11¼	3 6¾	2 6¼	2 3
I	1 8	1 6	1 1½	0 11	1 4½	1 3	0 11	0 9½
J	12 8½	11 7½	8 0	6 4	9 8	9 6	7 4¼	5 6
K	4 8	4 5	3 4	2 7¼	4 1	3 8¼	2 7¼	2 3½
L	2 2	2 0	1 6	1 2½	1 9½	1 9	1 2½	1 ½
M	0 7	0 6	0 4½	0 3¼	0 5½	0 5¼	0 4	0 3⅛
N	1 3	1 1	0 9	0 7½	0 11	0 10¼	0 7¾	0 6⅜
O	0 8	0 7¼	0 5½	0 4¼	0 6½	0 6	0 4½	0 3¾
P	0 4¼	0 4	0 3	0 2½	0 3¾	0 3½	0 2⅝	0 2
Q	10 2	9 6	8 8½	5 3¾	8 3	8 0	6 4	4 6¼
R	0 8½	0 7¼	0 6	0 4¾	0 7	0 6½	0 5	0 4¼
S	0 7½	0 6½	0 5	0 4¼	0 6	0 5¼	0 4½	0 3⅝

INGLEFIELD ANCHOR.

Unit $A'' = .5693\sqrt[3]{W}$, where W = weight in lbs.



A = unit in inches.	$G = 2.24\ A.$
$B = 9.5\ A.$	$H = .624\ A.$
$C = 2.5\ A.$	$I = .773\ A.$
$D = 1.25\ A.$	$K = .70\ A.$
$E = .6\ A.$	$L = .50\ A.$
$F = .37\ A.$	$M = .85\ A.$

FIG. 215.

NUMBER OF DECK BOLTS PER 1000 BD. FT. OF LUMBER.

Width of plank, 1" — Butt of plank at every 26' 0".

Thickness of Plank.	Spacing of Frames in Inches.								Weight of 100 Bolts.	
	18"	20"	22"	24"	26"	28"	30"	32"	½"	⅝"
"									Lbs.	Lbs.
1½	2980	2712	2492	2312	2160	2024	1912	1812	....	....
2	2235	2034	1869	1734	1620	1518	1434	1359	22.60	39.40
2½	1785	1628	1495	1385	1295	1215	1145	1086	25.48	43.60
3	1490	1356	1246	1156	1080	1012	956	906	28.92	48.00
3½	1275	1162	1067	990	924	867	818	775	32.10	52.80
4	1118	1017	934	867	810	759	717	679	34.75	57.00
4½	994	904	831	771	720	675	637	604	39.40	61.40
5	893	814	748	693	648	608	573	543	40.50	65.55
5½	813	740	679	630	589	552	521	494	....	....
6	745	678	623	578	540	506	478	453	....	....

How to Use the Table. — At 4" thickness of plank by 5" wide, 24" spacing of frames, number of bolts will be $\frac{867}{5}$ = 173 bolts.

ANCHOR CRANE STRESSES.

In figuring the stresses on an anchor crane it is assumed that the post acts as a cantilever, the maximum stress on which occurs at the upper deck bearing. The jib is always exposed to a direct compression, while the tierods are subjected to tension. The weight of the crane itself may be omitted in the calculation, as the stresses which occur as a consequence thereof are of small importance compared with stresses produced by the weight suspended at the head.

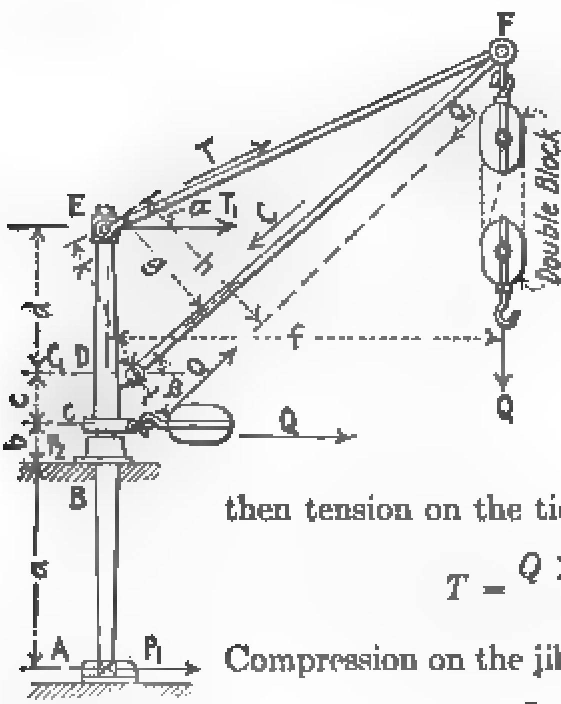


Fig. 216.

If Q = load in pounds,

Q_1 = load on hoisting rope in pounds,

f = spread in inches,

then tension on the tierods: —

$$T = \frac{Q \times f + Q_1 \times l}{k}.$$

Compression on the jib. —

$$C = \frac{Q \times f + Q_1 \times h}{g}.$$

If arrangement of blocks as shown, then

$$Q_1 = \frac{Q}{4}.$$

In calculating the dimensions of the crane post the load on the hoisting rope = Q_1 applied at the foot block, usually fitted to a wrought iron ring around the post, has to be taken into account. Note that this block should be placed as low as possible to reduce the stresses on the post.

The shearing stresses at A: The shearing stresses at B:

$$P_1 = \frac{Q \times f + Q_1 \times b}{a}. \qquad P_2 = \frac{Q \times f + Q_1(a + b)}{a}.$$

Now that the forces in all the points A, B, C, D and E are known the bending moment in way of each one has to be figured out.

As for T and C, bending stresses will be produced only from the horizontal components $T_1 = T \times \cos\alpha$ and $C_1 = C \times \cos\beta$, while of the vertical components T_2 and C_2 equal to $T \times \sin\alpha$ and $C \times \cos\beta$ respectively. T_2 will subject the post to tension on the part DE, while $C_2 - T_2$ will act as a compressive load between A and D. As the forces keep the crane in equilibrium, it will be seen that:

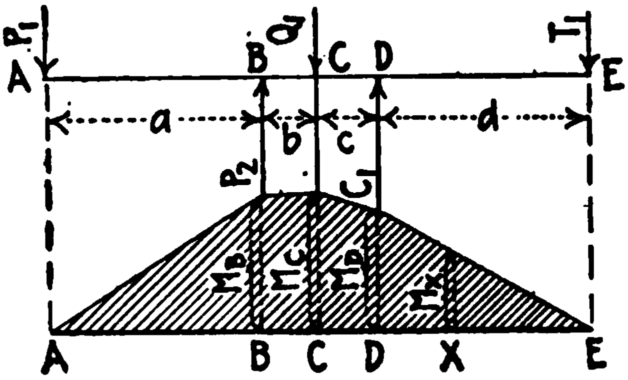


FIG. 217.

$$P_1 + Q_1 + T_1 \text{ must equal } P_2 + C_1.$$

Bending moment at A, $M_a = 0$.

Bending moment at B, $M_b = P_1 \times a$.

Bending moment at C, $M_c = P_1 = P_1\,(a + b) - P_2 \times b$.

Bending moment at D, $M_d = P_1\,(a + b + c) - P_2\,(b + c)$
$+ Q_1 \times C$, or also $M_d = T_1 \times d$.

Diagram of Bending Moments.—Along the vertical lines at B, C and D set off at any scale the bending moments as found above, and join the points as shown on sketch. From this diagram the moment Mx at any intermediate point may be scaled.

Graphic Method to Determine T and S.—The stresses on the different members of the crane may be conveniently found by graphic construction, and in most cases the result thus obtained is sufficiently accurate for practical purposes.

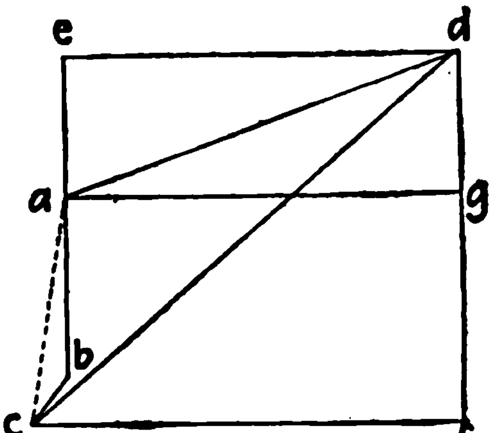


FIG. 218.

Take at any scale the vertical line ab to represent the load Q_1 draw bc parallel to the direction of the hoisting rope and equal to Q_1. The dotted line will therefore represent their resultant, and drawing ad and cd parallel respectively to DF and EF, these lines will represent the stresses on jib and tierods. From d and c draw horizontally the lines de and cf, and from d vertically the line df. Then we get $de = T_1 = T \times \cos\alpha$,

and $cf = C_1 = C \times \cos a$. Further $ae = T_2 = T \times \sin a$ and $df = C_2 = C \times \sin a$, the difference between these equal to fg representing the compression on the lower part of the post.

For getting out the shearing stress P_1 draw on a sketch of the crane a vertical line through F meeting the horizontal line from B at G, then draw AG and make AH at any scale equal to Q. Then HK will represent the shearing at A produced by Q_1. Draw AL horizontally and equal to BC and make AM equal to Q_1. If then from M a line is drawn parallel to BL the total shearing stress at A will be represented by $HK + AN$.

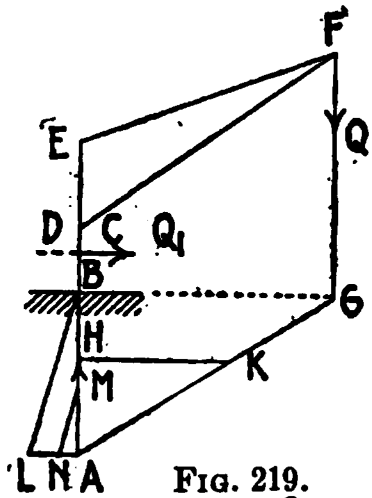


Fig. 219.

Calculation of Strength.—In figuring the dimensions of the different members in the anchor crane it is advisable not to use a factor of safety less than 6, which for ordinary wrought steel means a stress of material = 10,000 pounds per square inch, especially if the weight of the crane itself is omitted in the calculation. Based upon a factor of safety = 6, the following formulæ are derived:—

For the *tierods*, $d = 0.08 \sqrt{T}$ where d = diameter in inches and T = tension on tierods, two of which are supposed to be fitted.

For the *jib*, if solid circular section is being used,

$$d = 0.026 \sqrt[4]{Cl^2} \text{ where } d = \text{diameter in inches,}$$

$$C = \text{compression on jib and } l = \text{length of jib.}$$

For the *cranepost*, if solid circular section is being used,

$$d = 0.1 \sqrt[3]{M} \text{ where } d = \text{diameter in inches,}$$

and $\quad M$ = bending moment in inch-pounds.

In this latter formula the stress of material is assumed equal to 9500 pounds as against 10,000 pounds in the former ones to compensate for the stress produced by the compressive load $(C_2 - T_2)$ which is not included in the calculation.

FORMULAS FOR LAYING OUT BEVEL AND MITRE GEAR BLANKS.

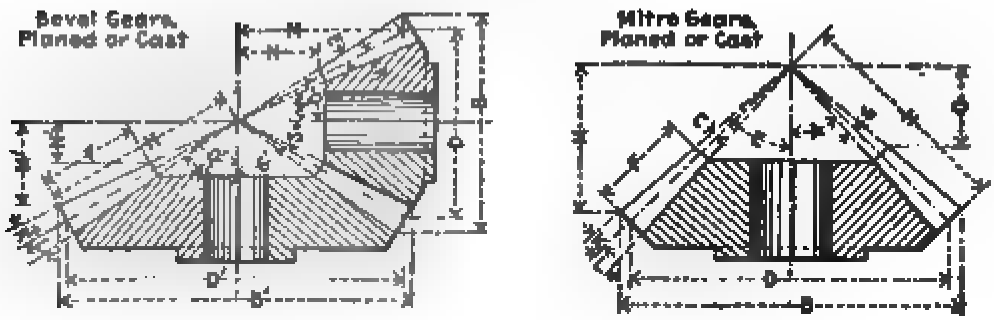


FIG. 220.

Formulas for Bevel Gears.

$$Y = \text{No. of teeth in pinion.}$$

$$D = \frac{YP}{\pi} = 0.318\,YP.$$

$$\operatorname{Tan} S = \frac{Y}{Y'} = \frac{D}{D'}.$$

$$B = D + (0.636\,P \cos S).$$

$$\operatorname{Tan} E = \frac{0.318\,P}{H} = \frac{K}{H} = \frac{2 \cos S'}{Y}.$$

$$\operatorname{Tan} R = \frac{0.368\,P}{H} = \frac{L}{H} = \frac{2.314 \cos S'}{Y}.$$

$$O = S + E.$$

$$A = S - R.$$

$$M = \frac{D'}{2} - (0.318\,P \sin S).$$

$$N = M - F \cos O.$$

$$P = \text{circular pitch.}$$

$$Y' = \text{no. of teeth in gear.}$$

$$D' = \frac{Y'P}{\pi} = 0.318\,Y'P; \quad S' = 90^\circ - S.$$

$$B' = D' + (0.636\,P \cos S').$$

$$N' = M' - F \cos O'.$$

$$H = \frac{D}{2 \cos S'}.$$

$$K = 0.318\,P; \quad L = 0.368\,P.$$
$$O' = S' + E; \quad A = S - R.$$
When to be cast $K = 0.3\,P. \qquad L = 0.4\,P.$
$$M' = \frac{D}{2} - (0.318\,P \sin S').$$

Formulas for Mitre Gears.

$P =$ circular pitch.

$N =$ number of teeth.

$$D = 0.318\,NP = \frac{NP}{\pi}.$$
$$B = D + (0.636\,P \sin 45°) = D + 0.449\,P.$$
$$A = 45° - S.$$
$$\text{Tan } S = \frac{L}{H} = \frac{0.368\,P}{D \times 0.707}.$$
$$E = 45° + C.$$
$$\text{Tan } C = \frac{K}{H} = \frac{0.318\,P}{D \times 0.707}.$$
$$M = \frac{D}{2} - (\sin 45° \times 0.318\,P) = \frac{D}{2} - 0.224\,P.$$
$$O = M - (F \cos E).$$
$$H = D \times 0.707.$$
$L = 0.368\,P; \quad K = 0.318\,P$ (when cast
$L = 0.4\,P; \quad K = 0.3\,P$).

NAVAL ANCHOR CRANE.

FIBRE STRESSES.

Crane Post at Forecastle Deck. —

Bending moment $Wl = 3{,}260{,}000$ in.-lbs.

Diameter $D = 16\frac{1}{2}$ ins.

Fibre stress $= f$.

$$\text{Moment of resistance} = f\,\frac{\frac{\pi}{64}D^4}{\frac{D}{2}} = f\,\frac{\pi}{32}D^3,$$

$$Wl = f\frac{\pi}{32}D^3.$$

$$f = \frac{Wl\,32}{\pi D^3} = \frac{3{,}260{,}000 \times 32}{\pi \times 16.5^3} = 7390 \text{ lbs. per sq. in.}$$

At A:

$$Wl = 2{,}405{,}000 \text{ in.-lbs.}, \quad D = 16\tfrac{1}{2} \text{ ins.}$$

$$f = \frac{Wl\,32}{\pi D^3} = \frac{2{,}405{,}000 \times 32}{\pi \times 16.5^3} = 5460 \text{ lbs. per sq. in.}$$

At B:

$$Wl = 1{,}577{,}000 \text{ in.-lbs.}, \quad D = 13.25 \text{ ins.}$$

$$f = \frac{Wl\,32}{\pi D^3} = \frac{1{,}577{,}000 \times 32}{\pi \times 13.25^3} = 6910 \text{ lbs. per sq. in.}$$

At C:

$$Wl = 1{,}150{,}000 \text{ in.-lbs.}, \quad D = 11.6 \text{ ins.}$$

$$f = \frac{Wl\,32}{\pi D^3} = \frac{1{,}150{,}000 \times 32}{\pi \times 11.6^3} = 7500 \text{ lbs. per sq. in.}$$

At D:

$$Wl = 725{,}000 \text{ in.-lbs.}, \quad D = 9.95 \text{ ins.}$$

$$f = \frac{Wl\,32}{\pi D^3} = \frac{725{,}000 \times 32}{\pi \times 9.95^3} = 7500 \text{ lbs. per sq. in.}$$

At E:

$$W = 300{,}000 \text{ in.-lbs.}, \quad D = 8.25 \text{ ins.}$$

$$f = \frac{Wl\,32}{D^3} = \frac{300{,}000 \times 32}{\pi \times 8.25^3} = 5450 \text{ lbs. per sq. in.}$$

Jib. — Total compression on jib — P = 80,000 lbs. + 3500 lbs. = 83,500 lbs. 8-inch extra strong pipe, outside diameter D = 8.625 ins., inside diameter d = 7.625 ins.

Modulus of elasticity E = 25,000,000.

Moment of inertia $I = \frac{\pi}{64}(D^4 - d^4) = \frac{\pi}{64}(8.625^4 - 7.625)^4 = 106.$

Length l = 189 ins.

Coefficient of safety = n.

$$P = \frac{\pi^3}{n} \cdot \frac{EI}{l^2}; \quad n = \frac{\pi^2 E \cdot I}{P \cdot l^2} = \frac{2 \times 25{,}000{,}000 \times 106}{83{,}500 \times 189^2} = 9.$$

DIAGRAM OF STRESSES AND BENDING MOMENTS ON ANCHOR CRANE.

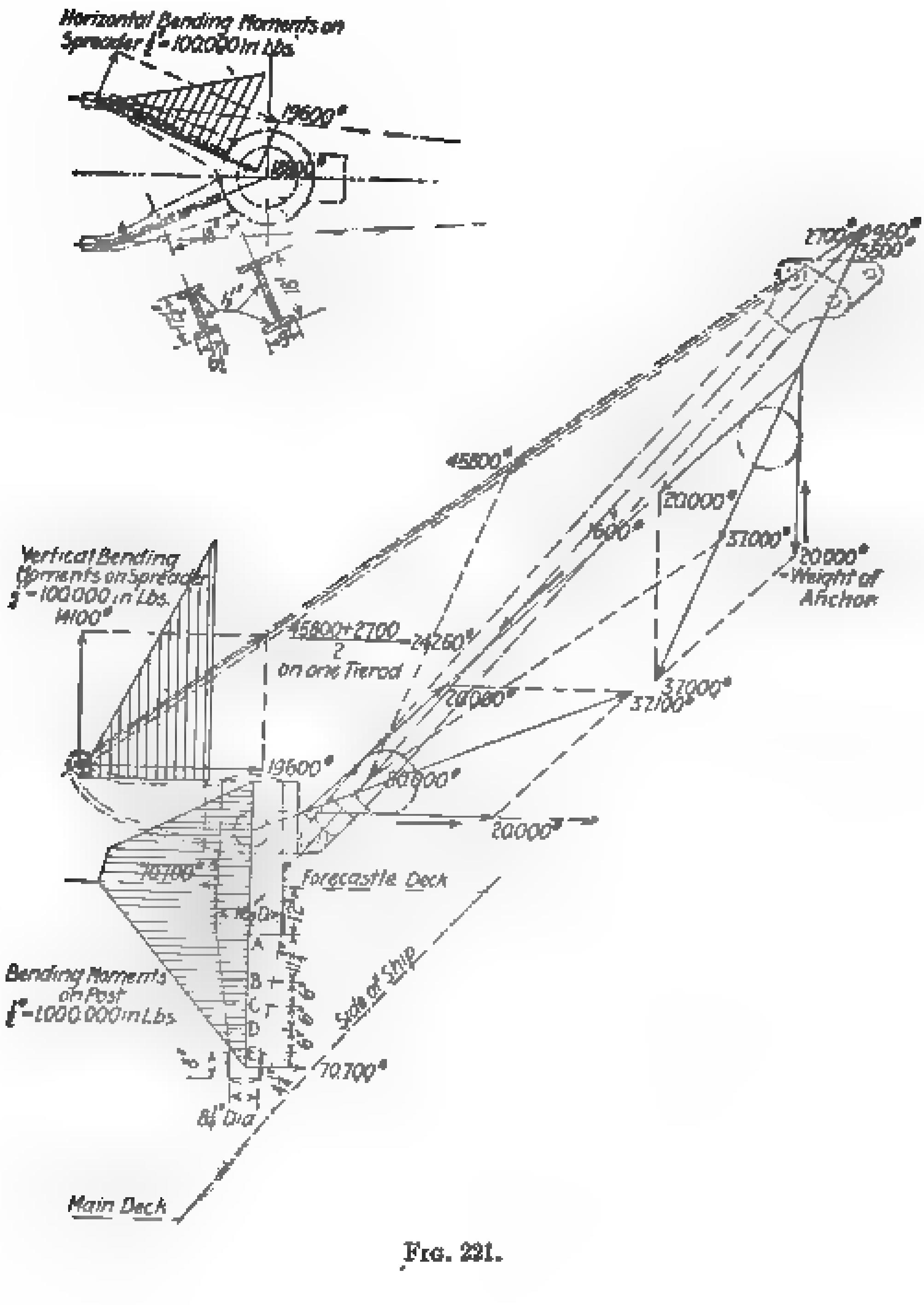


Fig. 221.

Area of section = 12.7 sq. ins.

$$\text{Fibre stress} = \frac{83{,}500}{12.7} = 6580 \text{ lbs. per sq. in.}$$

Tie Rods. — Diameter = $2\frac{1}{8}$ ins., tension on one tie rod = 24,250 ins.

$$\text{Fibre stress} = \frac{24{,}250}{\frac{2.125^2 \times \pi}{4}} = 6830 \text{ lbs.}$$

Spreader. — Section at hub of spreader.

Moment of inertia for axis $x - x$: = $I_x = 2267$,

$$\frac{I_x}{C_x} = \frac{2267}{9} = 252.$$

Bending moment for axis $x - x$: = 507,000 in.-lbs.

$$\text{Fibre stress } f_x = \frac{507{,}000}{252} = 2010 \text{ lbs. per sq. in.}$$

Moment of inertia for axis $y - y$: = $I_y = 186$,

$$\frac{I_y}{C_y} = \frac{186}{4.5} = 41.3.$$

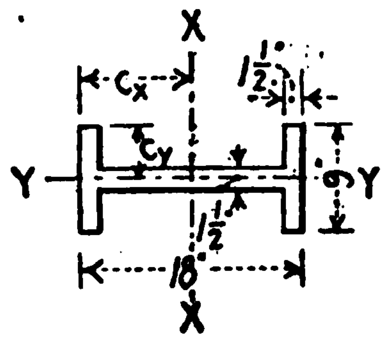


FIG. 222

Bending moment for axis $y - y$ = 200,000 in.-lbs.

$$\text{Fibre stress } f_y = \frac{200{,}000}{41.3}$$

$$= 4830 \text{ lbs. per sq. in.}$$

Area of section = 49.5 sq. ins.

Compression, 18,800 lbs.

$$\text{Fibre stress } f_c = \frac{18{,}800}{49.5} = 380 \text{ lbs. per sq. in.}$$

Total fibre stress

$$f_x + f_y + f_k = 2010 + 4830 + 380 = 7220 \text{ lbs. per sq. in.}$$

Section 18 ins. from hub.

$$\frac{I_x}{C_x} = \frac{701}{6.25} = 112.$$

Bending moment for axis $x - x$ = 267,000 in.-lbs.

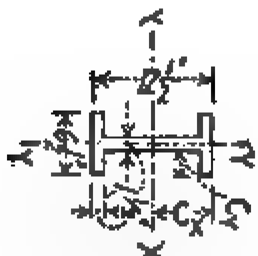


Fig. 223.

$$\text{Fibre stress } f_x = \frac{267{,}000}{112} = 2380 \text{ lbs. per sq. in.,}$$

$$\frac{I_y}{C_y} = \frac{71\ 3}{3.25} = 21.9.$$

Bending moment for axis $y - y$ = 91,000 in.-lbs.

$$\text{Fibre stress } f_y = \frac{91{,}000}{21.9} = 4150 \text{ lbs. per sq. in.}$$

Area of section 33.8 sq. ins.

Compression, 18,800 lbs.

$$\text{Fibre stress } f_c = \frac{18{,}800}{33.8} = 560 \text{ lbs. per sq. in.}$$

$$\text{Total fibre stress} = f_x + f_y + f_c = 2390 + 4150 + 560$$
$$= 7100 \text{ lbs. per sq. in.}$$

Tie Rod Heel Pin. — Pin considered as beam uniformly loaded and fixed at ends.

$$\frac{Pl}{8} = f\,\frac{\pi}{32}\,D^3.$$

Tension on one tie rod P = 24,250 lbs.

$$f = \frac{Pl\,32}{8\,\pi D^3} = \frac{24{,}250 \times 5.5 \times 32}{8 \times \pi \times 2.875^3}$$

$$= 7150 \text{ lbs. per sq. in.}$$

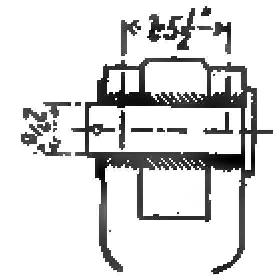


Fig. 224.

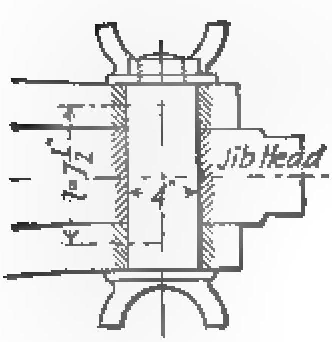


Fig. 225.

Tie Rod Eye Pin. — Figured as tie rod hub pin.

$$\frac{Pl}{8} = f\,\frac{\pi}{32}\,D^3,$$

$$f = \frac{Pl\,32}{8\,\pi\,D^3} = \frac{45{,}800 \times 7.5 \times 32}{8 \times \pi \times 4^3}$$

$$= 7240 \text{ lbs. per sq. in.}$$

DIMENSIONS OF ANCHOR CRANES.

Weight of Anchor × Spread in Feet.	Post at Deck.	One Tie Rod.	Two Tie Rods.	Jib.	Weight of Anchor × Spread in Feet.	Post at Deck.	One Tie Rod.	Two Tie Rods.	Jib.
Foot-cwts.	Dia.	Dia.	Dia. each.	Dia. middle.	Foot-cwts.	Dia.	Dia.	Dia. each.	Dia. middle.
	"	"	"	"		"	"	"	"
180	6	1¾	1 3/16	3	540	8¾	2⅜	1¾	4⅜
200	6¼	"	"	"	550	"	"	"	"
220	6½	1⅞	1¼	3¼	560	"	"	"	"
225	"	"	"	"	585	9	2½	1 13/16	4½
240	6¾	"	"	"	600	"	"	"	"
250	"	"	"	"	605	"	"	"	"
260	"	"	"	"	630	9¼	"	"	"
270	7	2	1⅜	3½	650	"	"	"	"
275	"	"	"	"	660	"	"	"	"
280	"	"	"	"	675	9½	2⅝	2	4¾
295	7¼	"	"	"	700	"	"	"	"
300	"	"	"	"	715	"	"	"	"
325	"	"	"	"	720	"	"	"	"
330	7½	2⅛	1 7/16	3¾	750	9¾	"	"	"
350	"	"	"	"	770	"	"	"	"
360	"	"	"	"	780	"	"	"	"
375	7¾	"	"	"	825	10	2¾	2 1/16	5
385	"	"	"	"	840	"	"	"	"
390	"	"	"	"	900	10¼	"	"	"
400	"	"	"	"	1,000	10⅜	2⅞	2⅛	5¼
405	8	2¼	1½	4	1,100	10½	"	"	"
420	"	"	"	"	1,200	10⅝	"	"	"
440	"	"	"	"	1,300	11	3	2¼	5½
450	8¼	"	"	"	1,400	11⅛	"	"	"
455	"	"	"	"	1,500	11¼	"	"	"
480	"	"	"	"	1,600	11⅜	3⅛	2⅜	5⅝
490	"	"	"	"	1,700	11½	"	"	"
495	8½	2⅜	1⅝	4¼	1,800	11⅝	3¼	2½	5¾
500	"	"	"	"	1,900	11¾	"	"	"
525	"	"	"	"	2,000	12	3⅜	"	6

NOTES ON ANCHOR CRANES.

The most suitable radius of crane to efficiently fish the anchor having been determined, this dimension in feet multiplied by the weight of anchor including stock, will give the moment in foot-cwts., to which reference must be made for the corresponding sizes of parts.

N.B. — These cranes are in accordance with Lloyd's requirements per Table 12, but for convenience the *moment* is given, which will be found much easier of application, and the table has been extended to deal with the heaviest anchors.

Of course where the ship is not classed to Lloyd's, the crane should be figured out with a factor of safety of eight, when it will be found that the sizes in this table, being empirical, may be considerably reduced.

The heavier sizes of cranes may with economy be built up with structural sections, or the post and jib may be formed with angle sections having lattice bracing.

It will also be found more economical to step the crane post or anchor deck in preference to housing it and making it revolve with the jib.

BRONZE SHIP'S BELL.

Copper 13, Tin 4 parts.

Directions for Laying Out. — Divide diameter of bell into [illegible] parts.

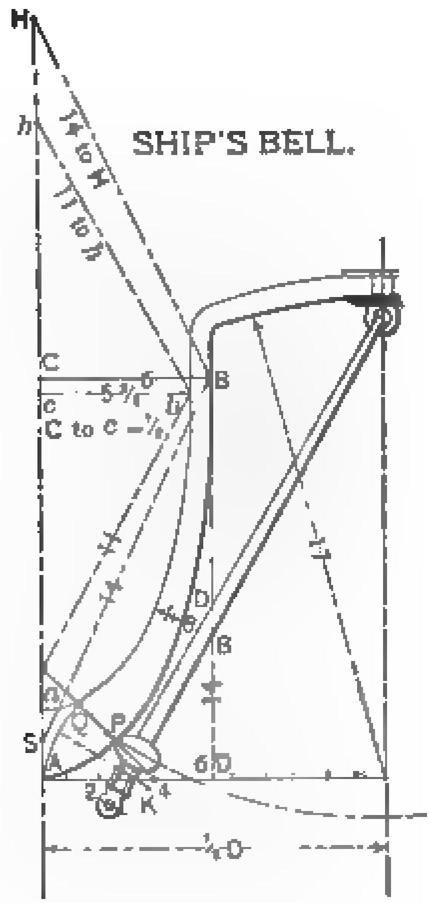


FIG. 226.

Then $AD =$ 6 parts.		$b - h = 11$	parts.
$DB = 14$	"	$A - 4 = 4$	"
$B - S = 14$	"	$P - Q = \frac{1}{13}$	diam.
$B - H = 14$	"	Rad. $K = 3\frac{1}{2}$	parts.
$C - c = \frac{1}{2}$	"	$A - 8 = 8$	"
$c - b = 5\frac{2}{3}$	"	Thickness at $8 = 1$	part.
$b - s = 11$	"		

Arc $A - G$, drawn with rad. of $3\frac{1}{2}$ parts from K, wherever that [illegible]ay fall, the rest of curve laid in by hand.
Rad. of crown 17 parts may be $16\frac{1}{2}$ to 19; thickness of bell at B, [illegible] parts = waist, sound bow = $\frac{1}{13}$ diam = QP.
Part of bell above bis. laid in as a cylinder.

WEIGHT OF BRONZE SHIP'S BELLS.

Diameter of Mouth in Inches.	Weight in Pounds.	Diameter of Mouth in Inches.	Weight in Pounds.
6	6	15	65
7	8	16	75
8	10	17	100
9	15	18	125
10	18	19	156
11	22	20	178
12	26	21	204
13	38	22	231
14	55		

Note. — Weights given are exclusive of hangers or belfry.

BELAY PINS.

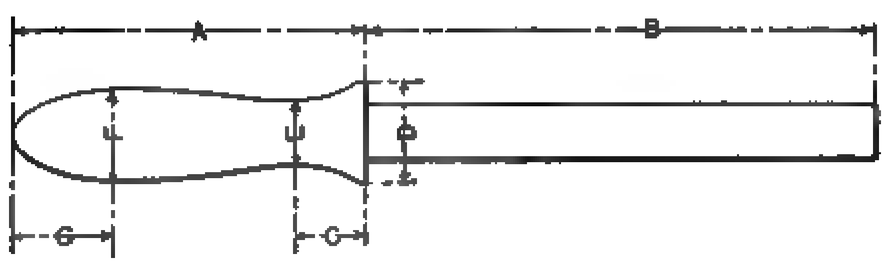
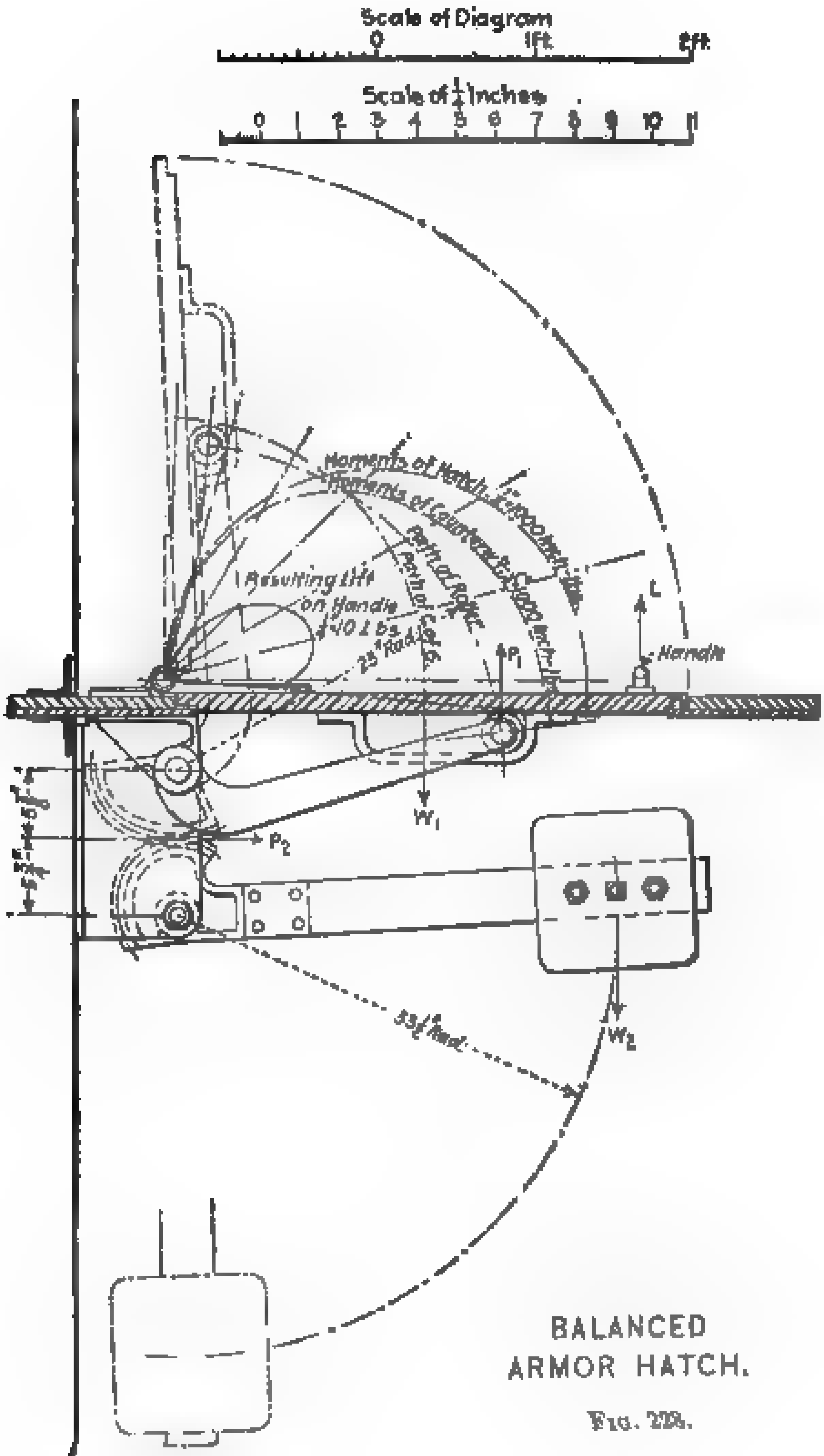


Fig. 227.

Size of Pin.	A.	B.	C.	D.	E.	F.	G.
"	"	"	"	"	"	"	"
$\frac{1}{2}$	4	5	$\frac{7}{8}$	$1\frac{1}{16}$	$\frac{9}{16}$	$1\frac{1}{8}$	$\frac{3}{4}$
$\frac{5}{8}$	$4\frac{1}{2}$	6	$\frac{15}{16}$	$1\frac{3}{16}$	$\frac{11}{16}$	$1\frac{1}{4}$	1
$\frac{3}{4}$	5	7	1	$1\frac{3}{8}$	$\frac{13}{16}$	$1\frac{5}{16}$	$1\frac{1}{4}$
$\frac{7}{8}$	$5\frac{1}{2}$	8	$1\frac{1}{16}$	$1\frac{1}{2}$	$\frac{15}{16}$	$1\frac{7}{16}$	$1\frac{1}{2}$
1	6	9	$1\frac{1}{8}$	$1\frac{11}{16}$	$1\frac{1}{16}$	$1\frac{1}{2}$	$1\frac{3}{4}$
$1\frac{1}{8}$	$6\frac{1}{4}$	10	$1\frac{1}{4}$	$1\frac{7}{8}$	$1\frac{3}{16}$	$1\frac{5}{8}$	2
$1\frac{1}{4}$	$7\frac{1}{2}$	11	$1\frac{5}{16}$	2	$1\frac{5}{16}$	$1\frac{3}{4}$	$2\frac{1}{4}$
$1\frac{3}{8}$	8	12	$1\frac{3}{8}$	$2\frac{3}{16}$	$1\frac{7}{16}$	$1\frac{7}{8}$	$2\frac{1}{2}$
$1\frac{1}{2}$	$8\frac{1}{2}$	13	$1\frac{1}{2}$	$2\frac{3}{8}$	$1\frac{9}{16}$	$1\frac{15}{16}$	$2\frac{3}{4}$



BALANCED
ARMOR HATCH.

FIG. 228.

BALANCED ARMORED HATCH.

Determination of Counterweight. —

Weight of hatch and fittings complete W_1 = 540 lbs.
Center of gravity of hatch from hinge pin 20 ins.
Lift applied on handle to start: L = 30 lbs.
Moment of hatch about hinge pin

$$W_1 \times 20 = 540 \times 20 = 10{,}800 \text{ in.-lbs.}$$

Deduct: applied lifting moment

$$L \times 36\tfrac{1}{2}'' = 30 \times 36\tfrac{1}{2}'' = 1{,}095 \text{ in.-lbs.}$$

Resulting moment about hinge = 9,705 in.-lbs.

$$\text{Pressure on roller } P_1 = \frac{9705}{26} = 373 \text{ lbs.}$$

Moments about centre of upper gear segment: —

$$373 \times 24.8 = P_2 \times 5.375 \text{ ins.}$$

$$P_2 = \frac{373 \times 24.8}{5.375} = 1722 \text{ lbs.}$$

+ 15 per cent for friction in teeth and bearings 258 lbs.
Total load on teeth = 1980 lbs.

Moments about centre of lower gear segment: —

$$1980 \times 5.75'' = W_2 \times 33.5'',$$

$$W_2 = \frac{1980 \times 5.75}{33.5} = 340 \text{ lbs.} = \text{weight of counterweight.}$$

Strength of Teeth for Gear Segments. — Lewis formula: —

W = s. p. f. y.,
W = load on teeth = 1980 lbs.,
s = 8000 lbs. per sq. in. (manganese bronze),
p = pitch,
f = face = $2p$,
y = coefficient = 0.1,

$$1980 = 8000 \times p \times 2p \times 0.1,$$

$$p = \sqrt{\frac{1980}{8000 \times 2 \times 0.1}} = 1.13'', \text{ say } 1\tfrac{1}{4}'' \text{ pitch, } 2\tfrac{1}{2}'' \text{ face.}$$

Strength of Upper Shaft. — Distance between bearings about 8″.

$$\text{Maximum bending moment } M_b = \frac{1730 \times 8}{8} = 1730 \text{ in.-lbs.}$$

Maximum twisting moment $M_t = 1730 \times 5.375 = 9300$ in.-lbs.
Equivalent bending moment $M = 0.35\,M_b + 0.65\,M_t = 0.35 \times 1730 + 0.65 \times 9300 = 6650$ in.-lbs.

$$M = \frac{\pi}{32} d^3 \times f; \quad f = 10{,}000 \text{ lbs. per sq. in.,}$$

$$d = \sqrt[3]{\frac{6650 \times 32}{\pi \times 10{,}000}} = 1.9'', \text{ make } 2'' \text{ to allow for keyways, etc.}$$

SHIP'S BOLLARDS (STANDARD).

Bollards are invariably made of cast iron of good quality, and should be fairly smooth castings. In small yacht and high class work they are sometimes made of gunmetal, and in battleships of steel. The bolt holes should not be cored but drilled and countersunk afterwards, the bolts being of BB iron or steel with full countersunk heads.

The diameter B of the barrel should be in accordance with the sizes given in the table, opposite the corresponding length of vessel, and with this dimension as a unit the proportionate sizes of the various parts calculated from the appended proportion table and diagram :

Diameter of bollard	$B = 1.$
Centres	$C = 2.83$
Height	$H = 1.77$
Length	$L = 5.22$
Width of base	$W = 1.50$
Ends	$E = 1.20$
Diameter of top	$D = 1.16$
Depth of ridge	$R = .33$
Thickness of base	$T = .17$
Thickness of side	$S = .12$
Moulding at top	$M = .16$

STANDARD BOLLARDS

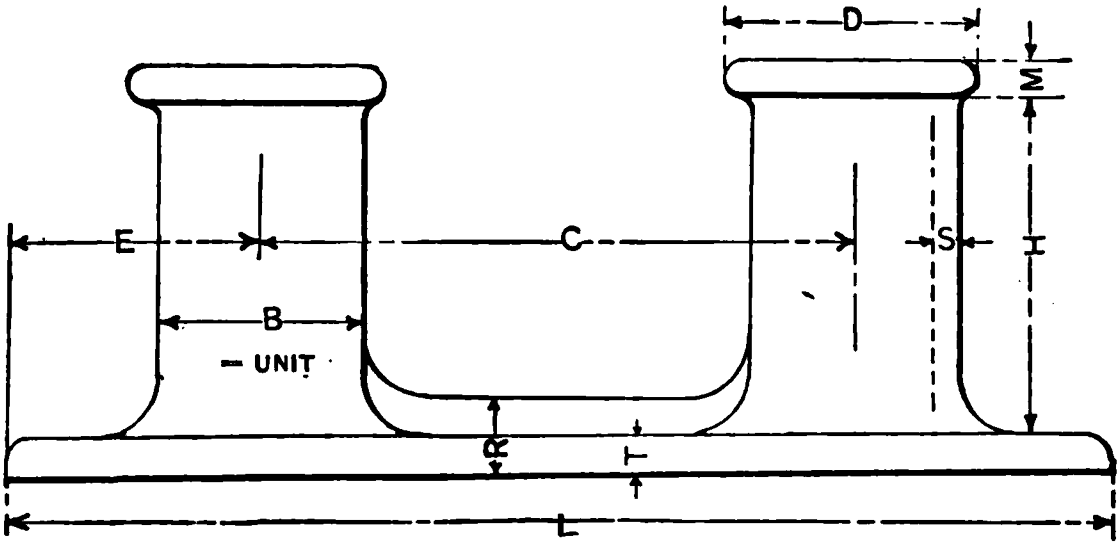


FIG. 229.

TABLE OF BOLLARDS (Cast Iron).

LENGTH OF SHIP.	DIMENSION *B*.	APPROXIMATE WEIGHT.	LENGTH OF SHIP.	DIMENSION *B*.	APPROXIMATE WEIGHT.
Ft.	Ins.	Lbs.	Ft.	Ins.	Lbs.
60	3	40	420	13½	1,710
80	3½	50	440	14	1,900
100	4	60	460	14½	2,100
110	4½	72	480	15	2,310
120	5	85	500	15½	2,525
140	5½	110	520	16	2,750
160	6	145	540	16½	3,000
170	6½	185	560	17	3,250
180	7	235	580	17½	3,540
190	7½	295	600	18	3,850
200	8	360	620	18½	4,140
210	8½	430	640	19	4,440
220	9	510	660	19½	4,810
240	9½	605	680	20	5,160
280	10	700	700	20½	5,560
300	10½	815	720	21	5,960
320	11	935	740	21½	6,390
340	11½	1,070	760	22	6,780
360	12	1,210	780	22½	7,240
380	12½	1,375	800	23	7,660
400	13	1,530	850	24	8,560

N.B. — The extra heavy bollards on forecastle head and quarters should *be ¼ larger than given in* table for the corresponding length of ship.

WIRE ROPE SNATCH BLOCKS.

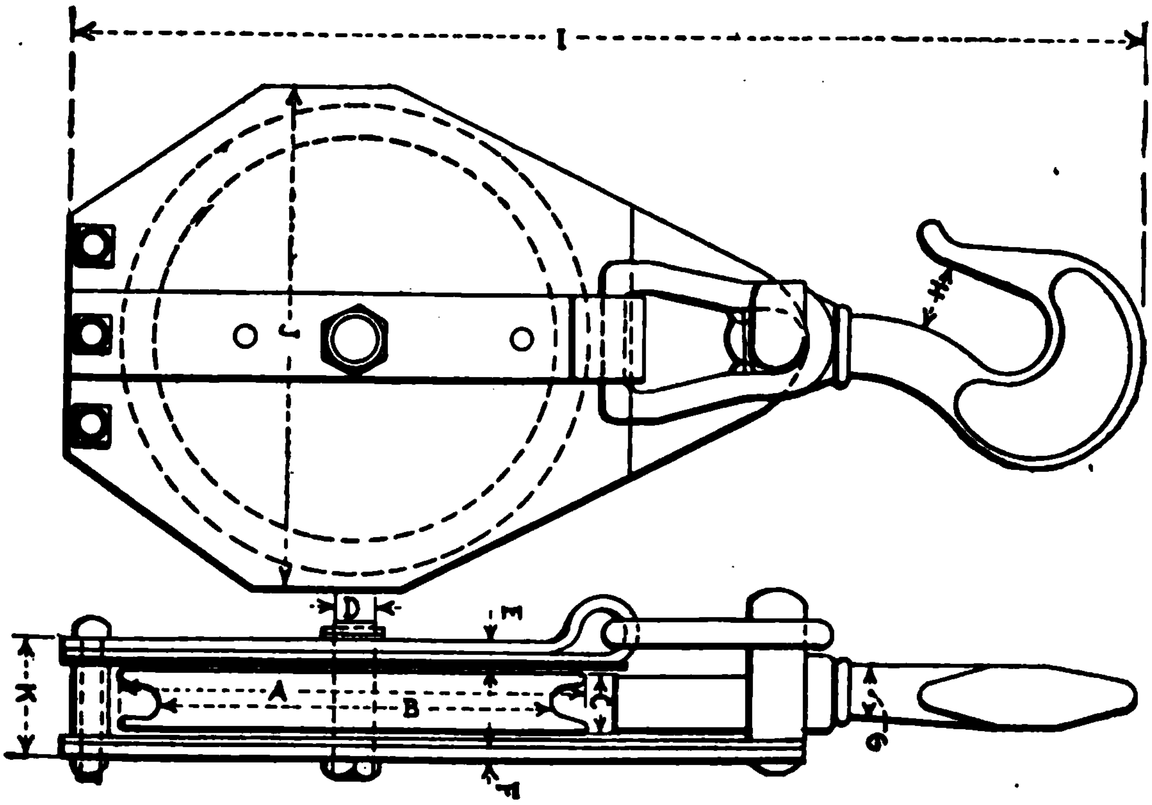


FIG. 230.

SIZE OF BLOCK.			10 INS.	12 INS.	14 INS.	16 INS.	18 INS.
			"	"	"	"	"
Sheave	Outside diameter	A	10	12	14	16	18
	Diameter bottom of groove	B	8½	10	11½	13½	15½
	Thickness	C	1¼	1½	1½	1¾	1¾
	Pin	D	1	1⅛	1¼	1½	1½
Hinge	Wire	....	½–⅝	⅝–¾	¾–⅞	⅞	1
	Short strap	E	2×¼	2¼×¼	2½×¼	3½×½	3½×½
	Long strap	F	2×½	2¼×½	2½×½	3½×½	3½×½
Hook	Diameter	G	1⅝	1¾	1⅞	2	2¼
	Opening	H	2	2¼	2½	2¾	3
Block	Length over all	I	24	27	30	39	46
	Width	J	10¾	12¾	15	17	19
	Thickness	K	4	3½	3½	4½	4½
	Weight	....	48 lbs.	70 lbs.	104 lbs.	140 lbs.	175 lbs.

DIAMOND ROPE BLOCKS.

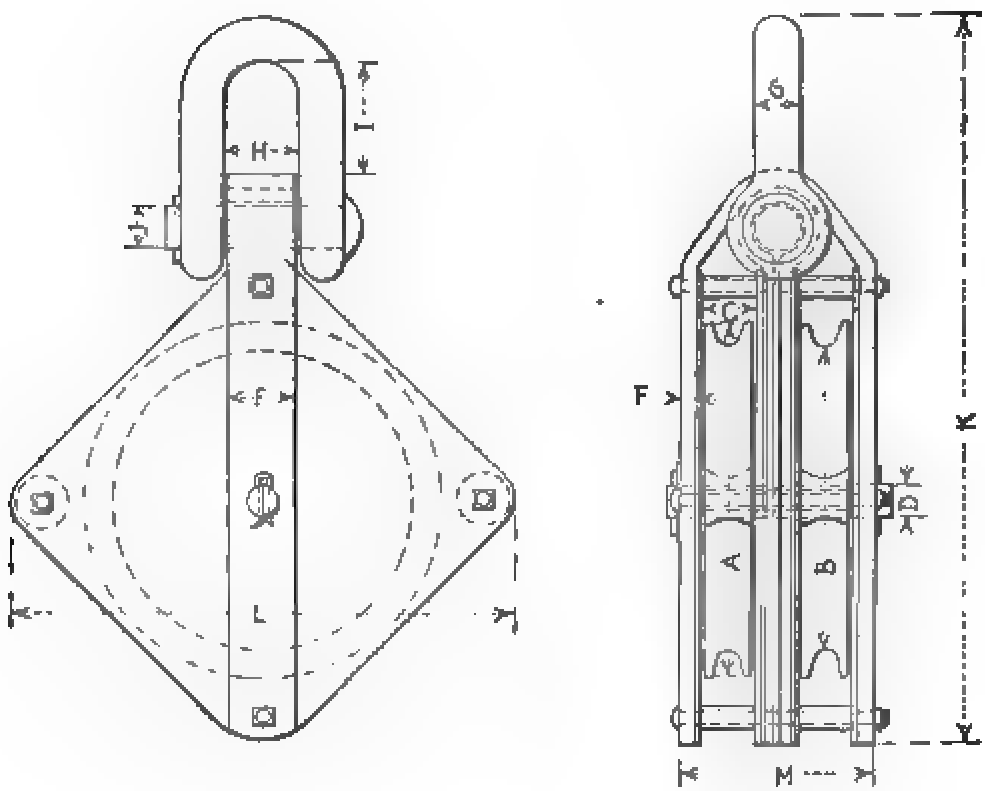


Fig. 231.

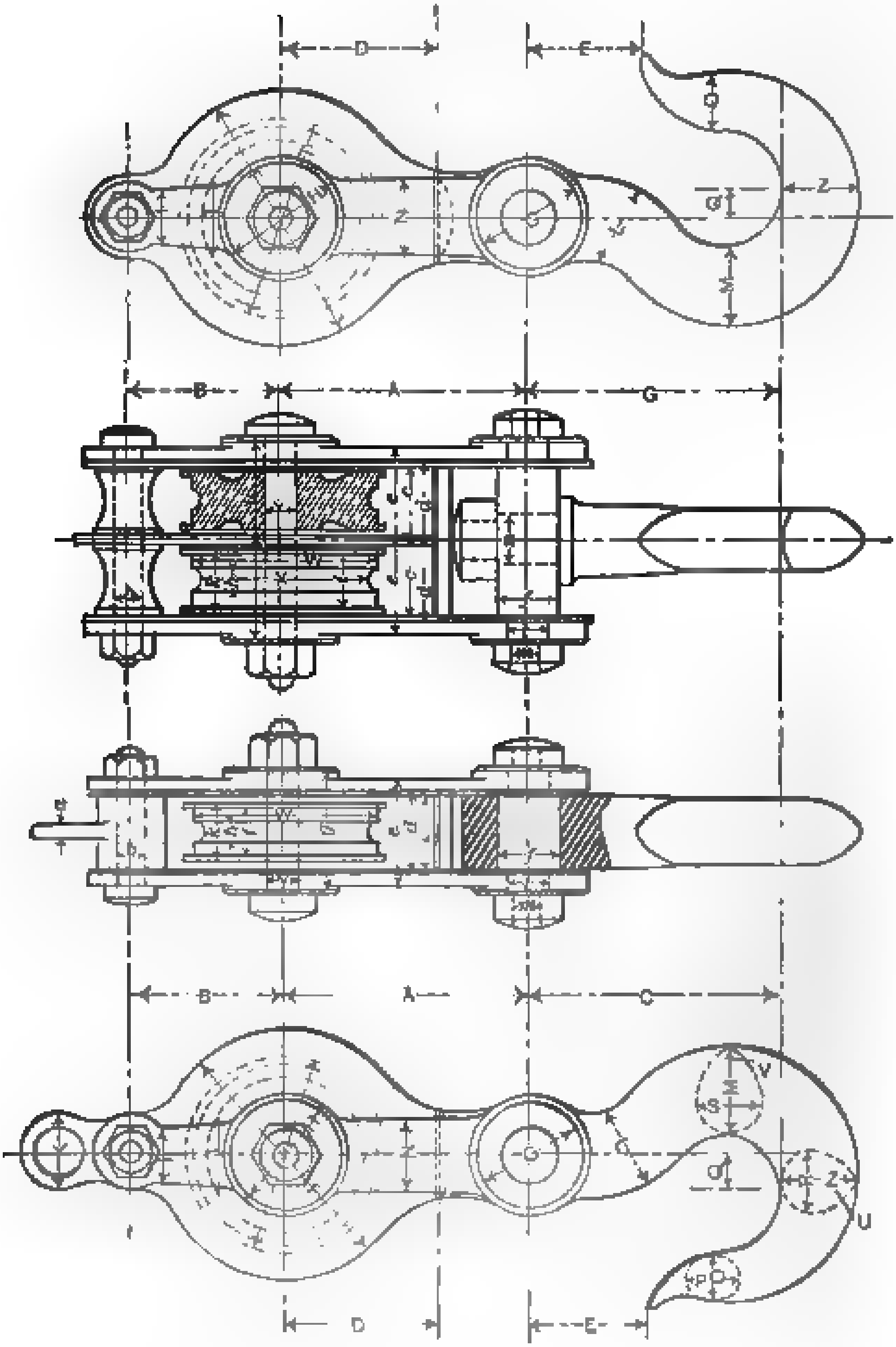
DIAMOND WIRE ROPE BLOCKS.

Kind.		Sheave.				Shackle.						Block.			
		A. Outside Diam.	B. Diam. Bottom Groove.	C. Thickness.	D. Pin.	E. Rope.	F. Strap.	G. Size.	H. Opening.	I. Length in Clear.	J. Diam. Pin.	K. Length Over All.	L. Width.	M. Thickness.	Weight.
		"	"	"	"	"	"	"	"	"	"	"	"	"	Lbs.
10″	Single...	10	8½	1¼	1	½ or ⅝	2 ×⅜	1⅜	2¼	4	1⅜	21	13½	2¾	43
	Double..	10	8½	1¼	1	½ or ⅝	2⅜×⅜	1⅜	2¼	3½	1⅝	21	13½	5½	70
	Triple...	10	8½	1¼	1	½ or ⅝	2⅜×⅜	1½	2¼	4	1½	22	13½	7½	100
12″	Single...	12	10	1½	1⅛	⅝ or ¾	2¼×½	1½	2⅜	4½	1½	25	17	3¼	72
	Double..	12	10	1½	1⅛	⅝ or ¾	2¼×½×½	1½	2⅜	4	1½	25	17	6½	130
	Triple...	12	10	1½	1⅛	⅝ or ¾	2¼×½×½	1⅝	2⅜	4	1⅝	26	17	8¾	180
						⅜									
14″	Single...	14	11½	1½	1¼	¾ or ⅞	2½×½	1⅝	2⅝	4¾	1⅝	28	19	3¼	89
	Double..	14	11½	1½	1¼	¾ or ⅞	2½×½×½	1⅝	2⅝	4½	1⅝	28	19	6½	160
	Triple...	14	11½	1½	1¼	or ⅞	2½×½×½	1¾	2⅝	5	1¾	29	19	8¾	231
16″	Single...	16	13½	1¾	1½	⅞	3½×½	2	3⅝	5½	2	34	23	3½	130
	Double..	16	13½	1¾	1½	⅞	3½×½×½	2	3⅝	5	2	34	23	7	244
	Triple...	16	13½	1¾	1½	⅞	3½×½×½	2¼	3⅝	6	2¼	36	23	9½	350
18″	Single...	18	15½	1¾	1½	1	3½×½	2	3⅝	5½	2	36	25	3½	164
	Double..	18	15½	1¾	1½	1	3½×½×½	2	3⅝	5	2	36	25	7	300
	Triple...	18	15½	1¾	1½	1	3½×½×½	2¼	3⅝	6	2¼	36	25	9½	450

STANDARD BLOCKS (Chain Sheaves).

	Single.				Double.			
	5 Tons.	10 Tons.	15 Tons.	20 Tons.	5 Tons.	10 Tons.	15 Tons.	20 Tons.
	″	″	″	″	″	″	″	″
A	4 3/4	7 1/2	9	11	4 3/4	7 1/2	9	11
B	3	4 1/2	5 7/8	7 1/4	3	4 1/2	5 7/8	7 1/4
C	4 7/8	7 7/16	10 1/2	13	4 7/8	7 7/16	10 1/2	13
D	3	4 1/4	5 1/4	6 1/2	3	4 1/4	5 1/4	6 1/2
E	2 1/8	3 1/2	5 5/8	6 3/4	. . .	. . .	. . .	. . .
F	4 7/8	6 3/8	8 1/4	10 1/8	. . .	. . .	. . .	. . .
G	2 5/16	2 7/8	3 1/2	4 1/4	. . .	. . .	. . .	. . .
H	2 5/16	2 7/8	3 1/2	4 1/2	. . .	. . .	. . .	. . .
I	1 1/4	1 1/2	1 7/8	2 3/8	. . .	. . .	. . .	. . .
J	1 1/2	1 11/16	2 1/8	2 1/2	. . .	. . .	. . .	. . .
K	1 1/2	2 1/2	2 3/4	3 1/8	. . .	. . .	. . .	. . .
L	1 3/8	1 13/16	2	2 3/4	. . .	. . .	. . .	. . .
M	1 3/4	2 9/16	2 7/8	4	. . .	. . .	. . .	. . .
N	1 9/16	2 3/8	2 3/4	3 1/2	. . .	. . .	. . .	. . .
O	7/8	1 1/2	2	2 1/2	. . .	. . .	. . .	. . .
P	1 1/16	1 5/8	2	2 1/4	. . .	. . .	. . .	. . .
Q	9/16	1 3/16	1 3/16	3/4	. . .	. . .	. . .	. . .
R	1 9/16	1 7/8	2	2 3/8	. . .	. . .	. . .	. . .
S	1 5/16	1 7/8	2	2 3/8	. . .	. . .	. . .	. . .
T	4	6	8	10	. . .	. . .	. . .	. . .
U	5/16	1/2	1/2	1/2	. . .	. . .	. . .	. . .
V	5/16	3/8	3/8	1/2	. . .	. . .	. . .	. . .
W	3 3/4	5 7/16	7 7/8	9 5/16	. . .	. . .	. . .	. . .
X	3 1/16	4 1/2	6 1/4	7 1/2	. . .	. . .	. . .	. . .
Y	3/4	1 1/8	1 1/4	1 1/2	. . .	. . .	. . .	. . .
Z	1 1/2	2	2 3/4	3 1/2	. . .	. . .	. . .	. . .
a	5/16	5/8	5/8	3/4	. . .	. . .	. . .	. . .
b	5/8	5/8	5/8	5/8	3/8	5/8	5/8	5/8
c	1 3/8	1 15/16	2 1/8	2 11/16	1 9/16	2 [illegible]	2 7/32	2 11/16
d	1 5/8	2 1/4	2 1/2	3 1/8	1 13/16	2 1/4	2 3/8	3
e	2 1/8	3	3 1/2	4 1/16	2 1/16	2 5/8	2 13/16	3 1/2
f	1 1/4	2 1/16	2 5/16	2 5/8	1 1/4	2 5/16	2 3/8	2 5/8
g	2 3/8	3 3/8	3 5/8	5	3 7/8	5 5/8	6	7 1/4
h	3/8	9/16	5/8	3/4	3/8	9/16	5/8	3/4
i	1 1/16	1 1/2	1 5/8	2 5/16	1 7/16	1 1/2	1 5/8	2 5/16
k	1 3/16	1 13/16	2	2 1/2	1 3/16	1 13/16	2	2 1/2
l	3/4	1 1/4	1 3/8	1 5/8	3/4	1 1/4	1 3/8	1 5/8
m	5/8	1 1/16	1 1/4	1 1/2	5/8	1 1/16	1 1/4	1 1/2
n	. . .	1 7/16	1 9/16	1 15/16	1 5/16	1 7/16	1 9/16	1 15/16

STANDARD BLOCKS



FIGS. 232–235.

25-TON BLOCK

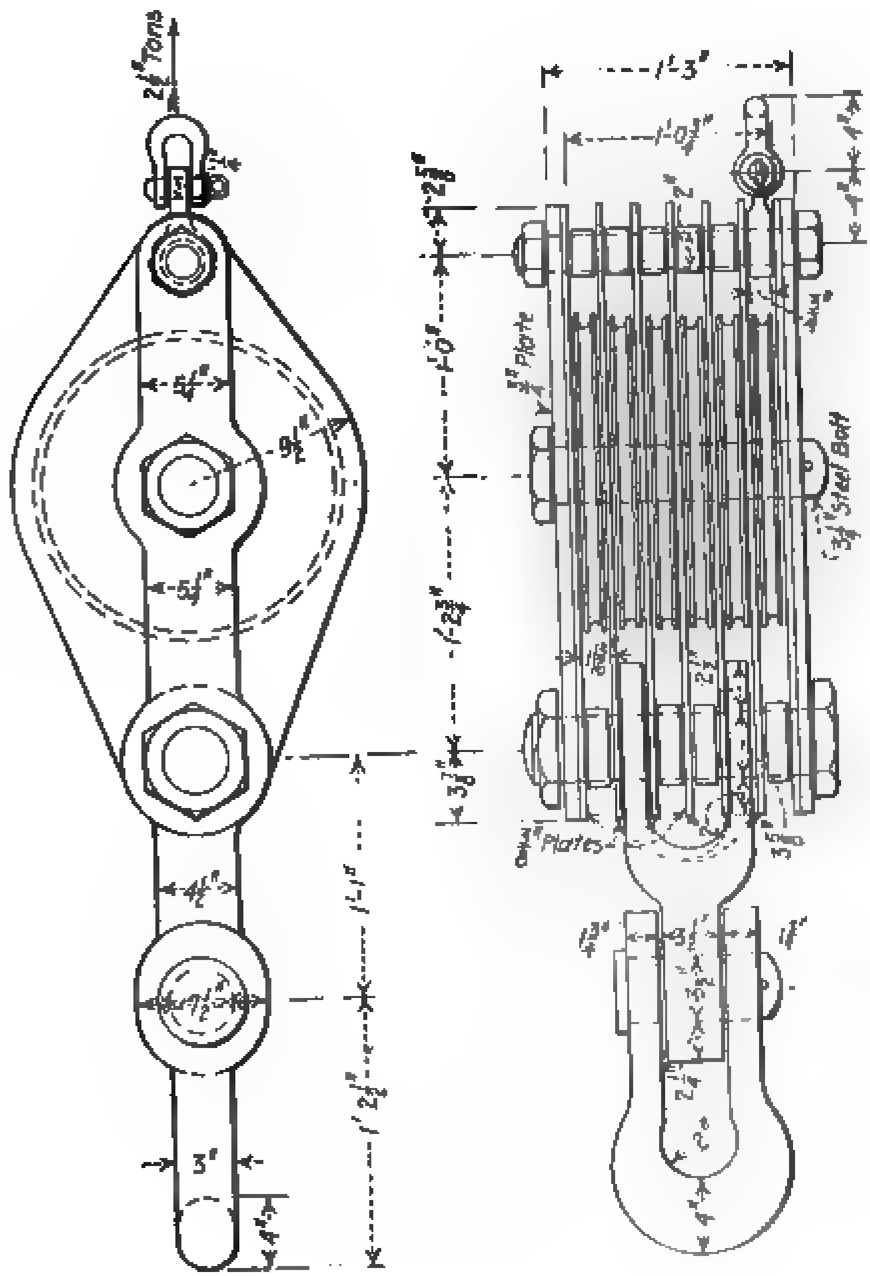
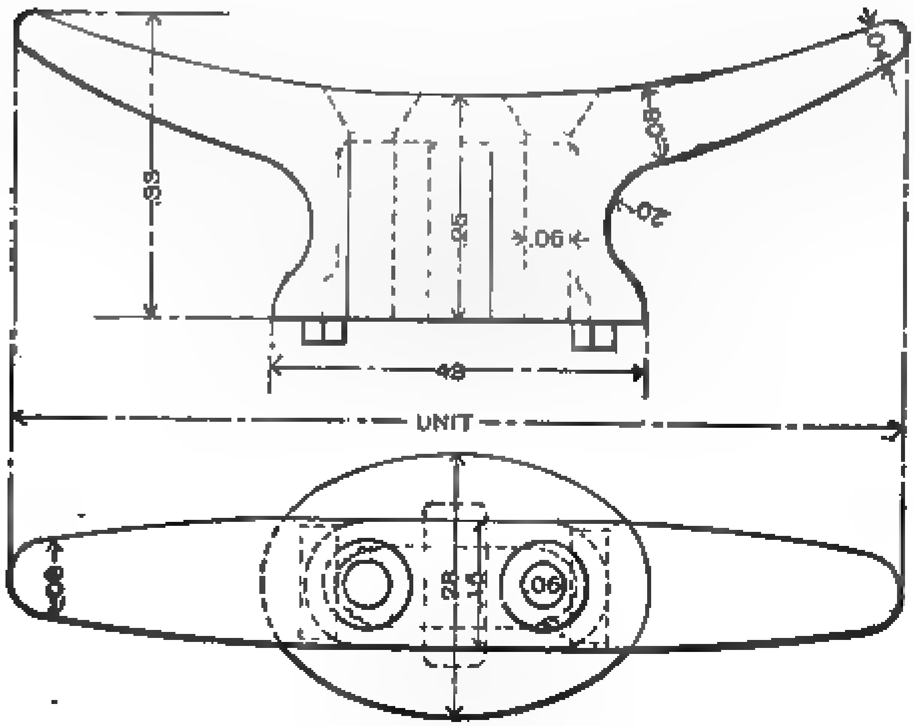


Fig. 236.

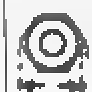
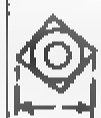
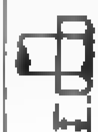


PROPORTIONS OF CLEATS
(Cast Steel)
FIG. 237.

CAST STEEL CLEATS SUITABLE FOR MANILA ROPE.

Circumference of Manila Rope.	Corresponding Length of Cleat. (Unit)	Weight in Pounds.	Circumference of Manila Rope.	Corresponding Length of Cleat. (Unit.)	Weight in Pounds.
In.	In.	Lbs.	In.	In.	Lbs.
1	6	2	3	14	12
1½	8	3	3½	[illegible]	17
2	10	6	4	18	22
2½	12	9	4½	20	31

UNITED STATES STANDARD

Bolt.		Diameters				Thickness.		Areas.	
Diameter.	Threads per Inch.				Bottom of Thread.			Bolt.	Bottom of Thread.
.25	20.	.5	.578	.707	.1850	25	.25	.0491	.0269
.3125	18.	.5938	.686	.840	.2403	.3125	2469	.0767	.0454
.375	16.	.6875	.794	.972	.2938	.375	.3438	.1104	.0678
4375	14.	.7813	.902	1 105	.3447	.4375	.3906	.1503	[illegible]
.5	13.	.875	1.011	1 237	.4001	.5	.4375	.1963	.1257
.5625	12.	.9688	1.119	1.370	.4542	.5625	.4844	.2485	.1621
.625	11.	1,0625	1.227	1.502	.5069	.625	.5313	.3068	.2018
.75	10.	1.25	1 444	1 768	.6201	75	.625	.4418	.3020
.875	9.	1 4375	1.660	2.033	.7307	.875	.7188	.6013	.4193
1.	8.	1.625	1 877	2.298	8376	1.	.8125	.7854	.5510
1.125	7.	1.8125	2.093	2.563	9394	1 125	.9063	.9940	.6931
1 25	7.	2.	2.310	2.828	1.0644	1 25	1.	1.2272	.8899
1.375	6.	2.1875	2.527	3.093	1 1585	1.375	1.0938	1 4849	1.0541
1.5	6.	2 375	2.743	3.358	1.2835	1.5	1 1875	1.7671	1.2938
1.625	5.5	2.5625	2.960	3.623	1.3883	1 625	1.2813	2.0739	1.5149
1.75	5.	2.75	3.176	3.889	1.4902	1 75	1.375	2.4053	1 7441
1.875	5.	2.9375	3.398	4.154	1.6152	1.875	1 4688	2.7612	2.0490
2.	4.5	3.125	3.609	4 419	1 7113	2.	1.5625	3 1416	2.3001
2.25	4.5	3.5	4.043	4.949	1 9613	2.25	1.75	3.9761	3.0213
2.5	4.	3.875	4.476	5.479	2 1752	2.5	1 9375	4.9087	3 7163
2.75	4.	4.25	4 909	6.010	2 4252	2.75	2 125	5.9396	4.6196
3.	3.5	4.625	5 342	6.540	2.6288	3	2.3125	7.0686	5.4277
3.25	3.5	5.	5 775	7.070	2.8788	3.25	2.5	8.2958	6.5092
3.5	3.25	5.375	6.208	7.600	3.1003	3.5	2.6875	9.6211	7.5491
3.75	3.	5.75	6.641	8.131	3.3170	3.75	2.875	11.0447	8.6412
4.	3.	6.125	7.074	8.661	3.5670	4	3.0625	12.5664	9.9929
4.25	2 875	6.5	7.508	9.191	3.7982	4 25	3 25	14.1863	11.3302
4.5	2 75	6.875	7.941	9.721	4.0276	4 5	3.4375	15 9043	12.7406
4.75	2 625	7 25	8.374	10.252	4 2551	4 75	3.625	17 7206	14.2206
5.	2.5	7 625	8.807	10.782	4.4804	5.	3.8125	19.6350	15.7659
5.25	2.5	8.	9 240	11.312	4 7804	5 25	4	21.6475	17.5745
5.5	2.375	8.375	9.673	11.842	4 9530	5.5	4 1875	23.7583	19.2678
5.75	2.375	8.75	10.106	12 373	5 2030	5 75	4 375	25.9672	21.2620
6.	2.25	9.125	10.539	12.903	5 4227	6.	4 5625	28.2743	23.0047

Diameter at Bottom of Thread. { Sharp V of 60° angle — Diameter bolt less (1 73205 × pitch of thread). "Sellers" or .75 depth of thread = Diameter bolt less (1.2990375 × pitch of thread).

Flats of  **or**  **nuts** = 1.5 diameter of bolt + .125″.

Corners of  **nuts** = **1.155 flats,**

BOLTS AND NUTS, ETC.

Tensile Strength			Shearing Strength.				Size of Split Pins S. G. and Inch.
			Full Bolt.		Bottom of Thread.		
At 10,000 lbs. per Sq. In.	At 12,500 lbs. per Sq. In.	At 17,500 lbs. per Sq. In.	At 7,500 lbs. per Sq. In	At 10,000 lbs. per Sq. In.	At 7,500 lbs. per Sq. In.	At 10,000 lbs. per Sq. In.	
269	336	471	368	491	202	269	No. 14
454	568	795	575	767	341	454	" 14
678	848	1,187	828	1,104	509	678	" 13
933	1,168	1,633	1,127	1,503	700	933	" 13
1,257	1,571	2,200	1,472	1,963	943	257	" 12
1,621	2,026	2,837	1,864	2,485	1,216	1,621	" 12
2,018	2,523	3,532	2,301	3,068	1,514	2,018	" 11
3,020	3,775	5,285	3,314	4,418	2,265	3,020	" 10
4,193	5,241	7,338	4,510	6,013	3,145	4,193	" 9
5,510	6,888	9,643	5,891	7,854	4,139	5,510	" 8
6,931	8,664	12,129	7,455	9,940	5,198	6,931	" 7
8,899	11,124	15,573	9,204	12,272	6,074	8,899	" 6
10,541	13,176	18,447	11,137	14,849	7,906	10,541	" 5
12,938	16,173	22,642	13,253	17,671	9,704	12,938	" 4
15,149	18,936	26,511	15,554	20,739	11,392	15,149	" 3
17,441	21,801	30,522	18,040	24,053	13,081	17,441	" 2
20,490	25,613	35,858	20,709	27,612	15,368	20,490	" 1
23,001	28,751	40,252	23,562	31,416	17,251	23,001	" 1
30,213	37,766	52,873	29,821	38,701	22,660	30,213	[illegible]
37,163	46,454	65,035	36,815	49,087	27,872	37,163	[illegible]
46,196	57,745	80,843	44,547	59,396	34,647	46,196	[illegible]
54,277	67,846	94,985	53,015	70,686	40,708	54,277	[illegible]
65,092	81,365	113,911	62,219	82,958	48,819	65,092	[illegible]
75,491	94,364	132,109	72,158	96,211	56,618	75,491	[illegible]
86,412	108,015	151,221	82,835	110,447	64,809	86,412	[illegible]
99,929	124,911	174,876	94,248	125,664	74,947	99,929	[illegible]
113,302	141,628	198,279	106,397	141,863	84,977	113,302	[illegible]
127,406	159,256	222,959	119,282	159,043	95,554	127,406	[illegible]
142,206	177,756	248,859	132,904	177,205	106,654	142,206	[illegible]
157,050	197,074	275,903	147,263	196,350	118,344	157,059	[illegible]
175,746	219,691	307,554	162,356	216,475	131,809	175,746	[illegible]
192,678	240,848	337,187	178,187	237,583	144,509	192,678	[illegible]
212,620	265,775	372,085	194,754	259,672	159,405	212,620	[illegible]
230,947	288,684	404,157	212,057	282,743	173,210	230,947	[illegible]

Corners of ⊡ nuts = 1 414 flats.

Thickness of nuts = diameter of bolt.

Thickness of heads = flats of heads and nuts ÷ 2.

Sizes of "Sellers" or Franklin Institute finished heads and nuts are (flats and thickness of U.S. rough and finished nuts) — .0625″. Rough heads, same thickness as U.S. nuts.

CHAIN PLATES.

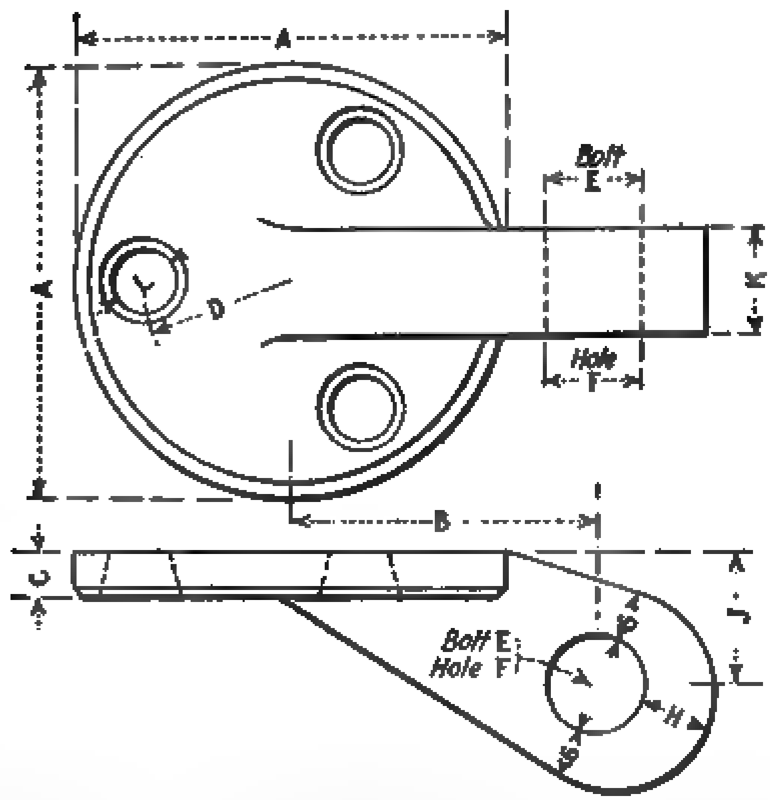


FIG. 238.

SIZE OF WIRE.	A	B	C	D	E	F	G	H	J	K	L
"	"	"	"	"	"	"	"	"	"	"	"
$2\frac{1}{4}$	$5\frac{1}{8}$	$3\frac{5}{8}$	$\frac{1}{2}$	$1\frac{3}{4}$	1	$1\frac{1}{8}$	$\frac{5}{8}$	$\frac{7}{8}$	$1\frac{7}{8}$	1	$\frac{5}{8}$
....	$5\frac{1}{4}$	$4\frac{1}{8}$	$\frac{1}{2}$	2	1	$1\frac{1}{8}$	$\frac{5}{8}$	$\frac{7}{8}$	$2\frac{1}{8}$	$1\frac{1}{8}$	$\frac{5}{8}$
$2\frac{1}{2}$	$6\frac{1}{2}$	$4\frac{1}{2}$	$\frac{1}{2}$	$2\frac{1}{4}$	1	$1\frac{1}{8}$	$\frac{7}{8}$	$\frac{15}{16}$	$2\frac{1}{8}$	$1\frac{1}{4}$	$\frac{5}{8}$
$3\frac{1}{4}$	7	$4\frac{3}{4}$	$\frac{5}{8}$	$2\frac{3}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$\frac{7}{8}$	$1\frac{1}{16}$	$2\frac{1}{8}$	$1\frac{3}{8}$	$\frac{3}{4}$
$3\frac{1}{2}$	$7\frac{1}{2}$	$4\frac{3}{4}$	$\frac{11}{16}$	$2\frac{1}{2}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$\frac{7}{8}$	$1\frac{1}{8}$	$2\frac{1}{4}$	$1\frac{7}{8}$	$\frac{3}{4}$
$3\frac{3}{4}$	$7\frac{1}{2}$	$5\frac{1}{4}$	$\frac{3}{4}$	$2\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{5}{8}$	1	$1\frac{1}{4}$	$2\frac{1}{4}$	$1\frac{7}{8}$	1
$4\frac{1}{2}$	$8\frac{1}{2}$	$5\frac{3}{4}$	$\frac{7}{8}$	$2\frac{3}{4}$	$1\frac{5}{8}$	$1\frac{3}{4}$	1	$1\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{1}{8}$	1
5	$8\frac{1}{2}$	$6\frac{1}{4}$	1	$2\frac{3}{4}$	$1\frac{7}{8}$	2	1	$1\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{8}$	$1\frac{1}{8}$

TABLE OF DIMENSIONS.

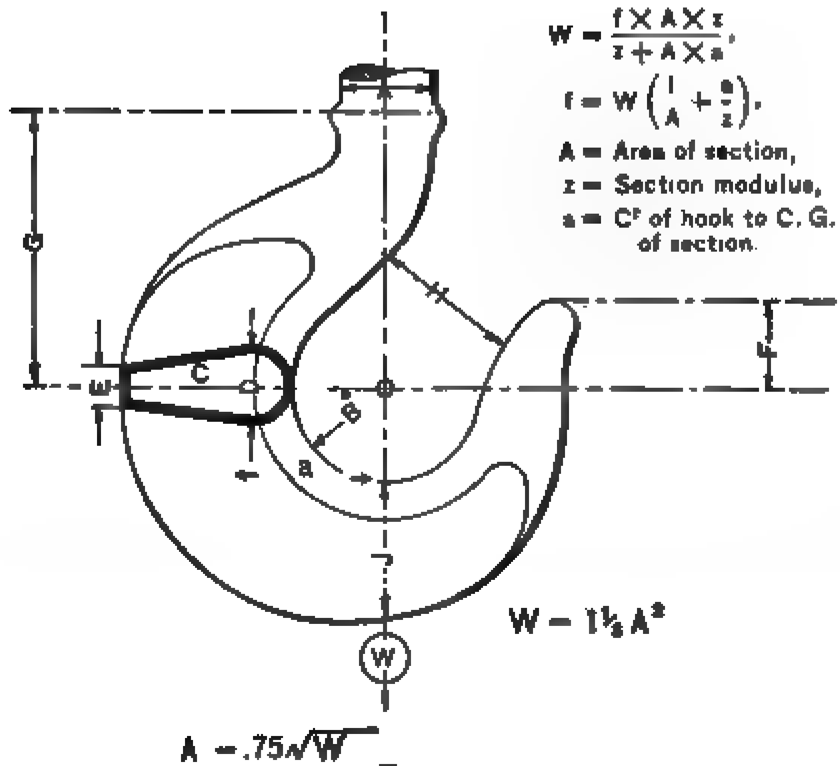


FIG. 239.

WORKING LOAD IN TONS	A = 1.00.	B = 1.00.	C = 1.80.	D = .80.	E = .40.	F = 1.00.	G = 3.00.	H = 1.60	J = 1.40
	In.	In.	In.	In.	In.	In.	In.	In.	In.
$\frac{1}{2}$	$\frac{5}{8}$	$\frac{5}{8}$	$1\frac{1}{8}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{5}{8}$	$1\frac{7}{8}$	1	$\frac{7}{8}$
$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$1\frac{3}{8}$	$\frac{5}{8}$	$\frac{5}{16}$	$\frac{3}{4}$	$2\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{8}$
1	$\frac{7}{8}$	$\frac{7}{8}$	$1\frac{9}{16}$	$\frac{11}{16}$	$\frac{3}{8}$	$\frac{7}{8}$	$2\frac{9}{16}$	$1\frac{3}{8}$	$1\frac{1}{4}$
$1\frac{1}{2}$	1	1	$1\frac{13}{16}$	$\frac{13}{16}$	$\frac{7}{16}$	1	3	$1\frac{5}{8}$	$1\frac{7}{16}$
2	$1\frac{1}{8}$	$1\frac{1}{8}$	2	$\frac{7}{8}$	$\frac{7}{16}$	$1\frac{1}{8}$	$3\frac{3}{8}$	$1\frac{13}{16}$	$1\frac{9}{16}$
3	$1\frac{3}{8}$	$1\frac{3}{8}$	$2\frac{1}{2}$	$1\frac{1}{8}$	$\frac{9}{16}$	$1\frac{3}{8}$	$4\frac{1}{8}$	$2\frac{1}{4}$	$1\frac{15}{16}$
5	$1\frac{5}{8}$	$1\frac{5}{8}$	$2\frac{15}{16}$	$1\frac{5}{16}$	$\frac{5}{8}$	$1\frac{5}{8}$	$4\frac{7}{8}$	$2\frac{9}{16}$	$2\frac{1}{4}$
7	$2\frac{1}{8}$	$2\frac{1}{8}$	$3\frac{13}{16}$	$1\frac{3}{4}$	$\frac{7}{8}$	$2\frac{1}{8}$	$6\frac{3}{8}$	$3\frac{7}{16}$	3
10	$2\frac{3}{8}$	$2\frac{3}{8}$	$4\frac{1}{4}$	$1\frac{7}{8}$	$\frac{15}{16}$	$2\frac{3}{8}$	$7\frac{1}{8}$	$3\frac{13}{16}$	$3\frac{3}{8}$
12	$2\frac{5}{8}$	$2\frac{5}{8}$	$4\frac{3}{4}$	$2\frac{1}{8}$	$1\frac{1}{16}$	$2\frac{5}{8}$	$7\frac{7}{8}$	$4\frac{1}{4}$	$3\frac{5}{8}$
15	3	3	$5\frac{7}{16}$	$2\frac{7}{16}$	$1\frac{1}{4}$	3	9	$4\frac{11}{16}$	$4\frac{1}{4}$
18	$3\frac{1}{4}$	$3\frac{1}{4}$	$5\frac{3}{4}$	$2\frac{5}{8}$	$1\frac{5}{16}$	$3\frac{1}{4}$	$9\frac{3}{4}$	$5\frac{1}{4}$	$4\frac{1}{2}$
21	$3\frac{1}{2}$	$3\frac{1}{2}$	$6\frac{5}{16}$	$2\frac{11}{16}$	$1\frac{3}{8}$	$3\frac{1}{2}$	$10\frac{1}{2}$	$5\frac{9}{16}$	$4\frac{7}{8}$
25	$3\frac{3}{4}$	$3\frac{3}{4}$	$6\frac{3}{4}$	3	$1\frac{1}{2}$	$3\frac{3}{4}$	$11\frac{1}{4}$	6	$5\frac{1}{4}$

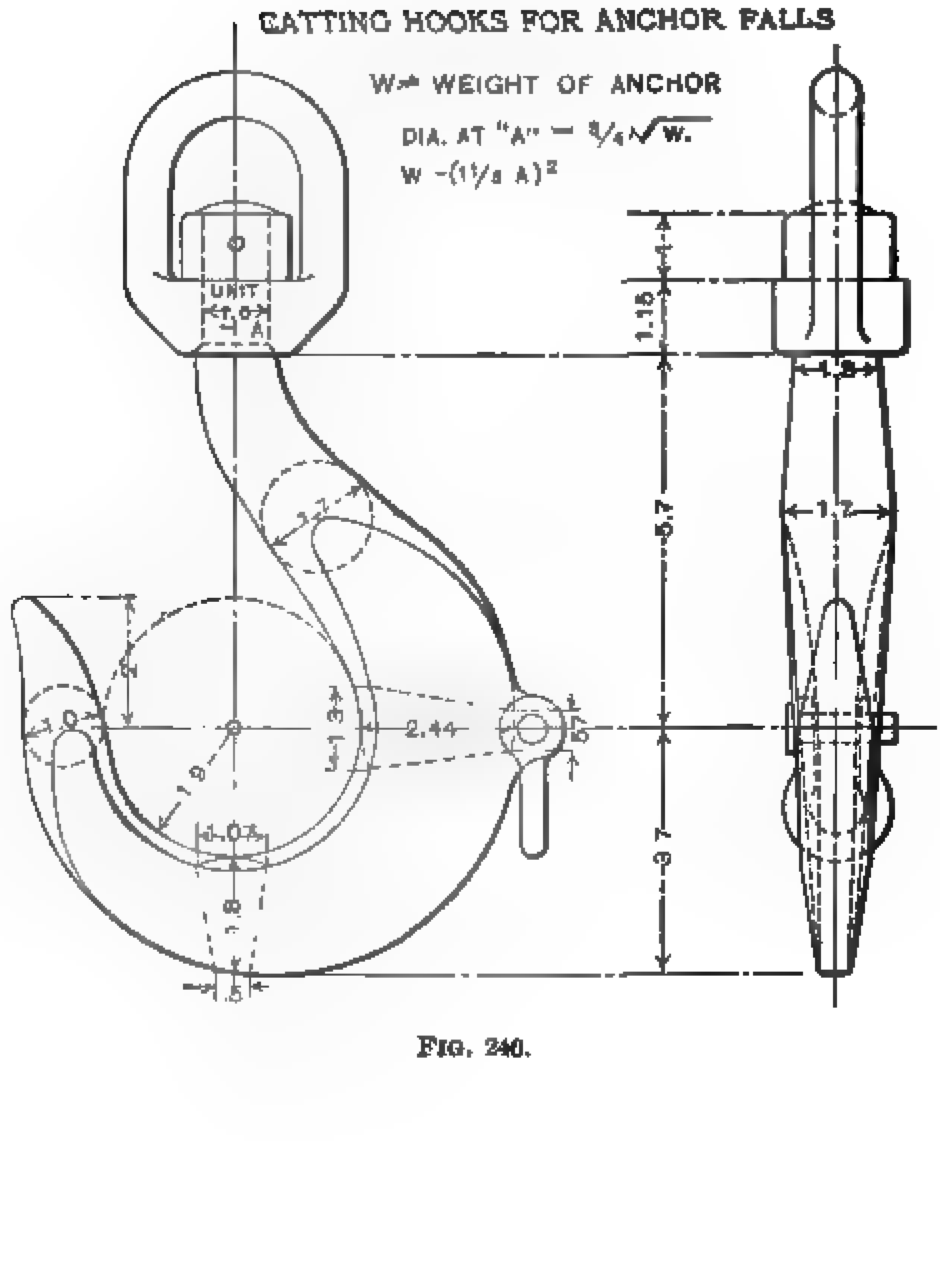

CATTING HOOKS FOR ANCHOR FALLS
W = WEIGHT OF ANCHOR
DIA. AT "A" = 3/4 √W.
W = (1 1/3 A)²
UNIT
1.0
A
1.15
5.7
1.7
1.0
2.44
1.3
1.9
1.07
.8
.5
3.7

Fig. 240.

LIST OF GEARS.

HOISTING.

Kind.	Face.	Teeth.	Pitch.	Pitch Dia.	Rev. per Min.
	In.		In.	In.	
pinion (motor)....	$4\frac{3}{8}$	14	$1\frac{3}{4}$ C.P.	7.799	400
gear..............	$4\frac{3}{8}$	40	$1\frac{3}{4}$ C.P.	22.282	140
....	....	Triple R.H. thrd.	3 pitch 9 lead	10	140
gear (drum).....	......	34	3 C.P.	32.468	12.35

dia. of coil of rope on drum = 31″ = 8.12′ circum.

r part hoist = $\dfrac{8.12 \times 12.35}{4}$ = 25.07′ per min. hoist.

TURNING.

Kind.	Face.	Teeth.	Pitch.	Pitch Dia.	Rev. per Min.
	In.		In.	In.	
pinion (motor)....	$4\frac{3}{8}$	15	$1\frac{3}{4}$ C.P.	8.356	365
gear..............	$4\frac{3}{8}$	43	$1\frac{3}{4}$ C.P.	23.953	127.3
....	....	Single R.H. thrd.	4 pitch 4 lead	10	127.3
gear..............	......	20	4 C.P.	25.465	6.366
pinion............	7	15	4 C.P.	19.099	6.366
lar rack...........	7	96	4 C.P.	122.231	0.995

NAVY BOAT CRANE.

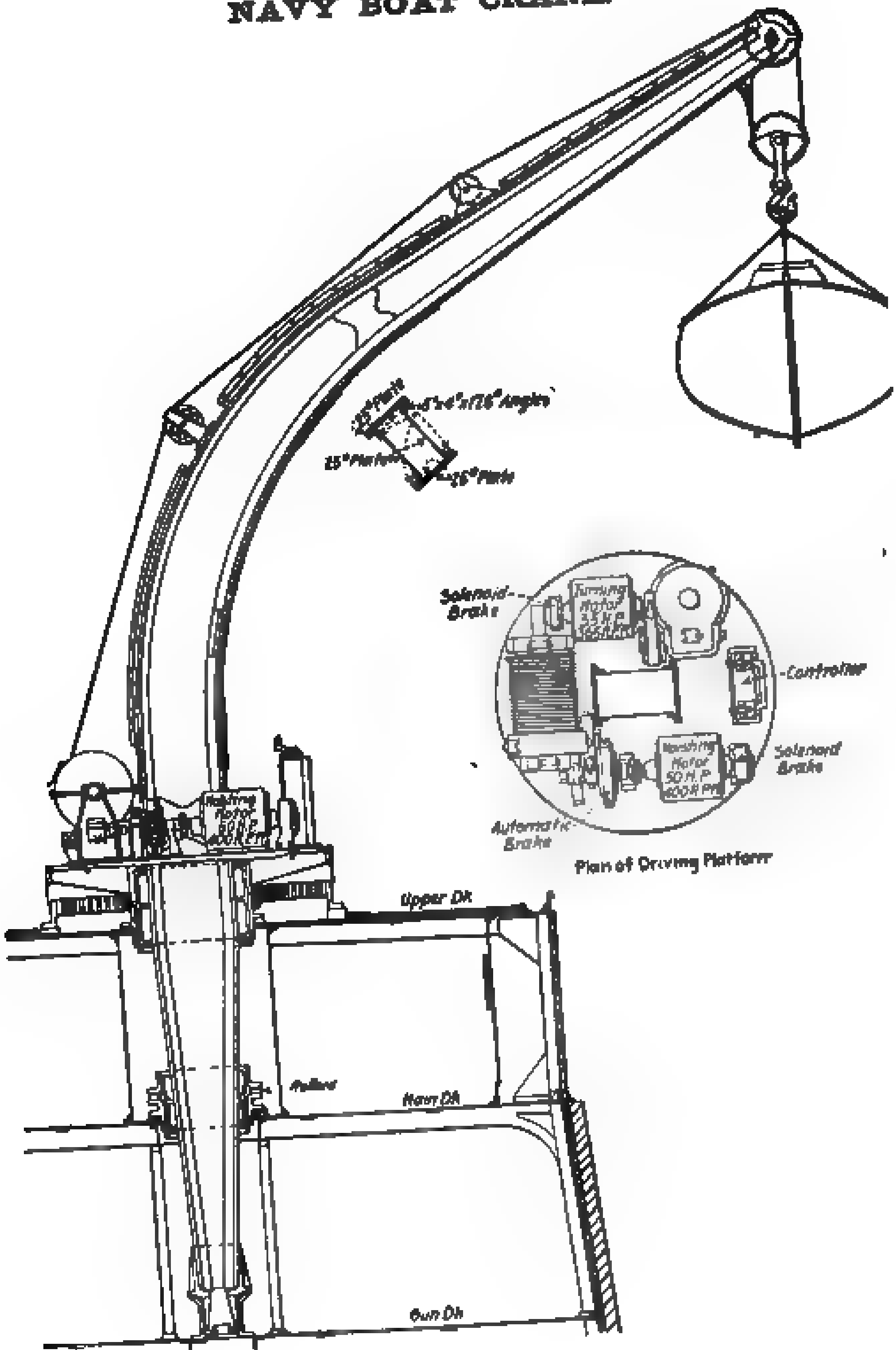


Fig. 241.

BOAT HANDLING ARRANGEMENT.

The laws of the principal maritime nations require that not only shall a stated number and kind of boats, lifeboat and working, be installed on board ship, varying of course with the particular requirements of the vessel itself and the trade in which it is employed, but also that these boats shall be efficiently installed on board ship and conveniently arranged with proper boat handling appliances.* To comply with these enactments various arrangements are adopted suited to the special conditions which obtain in the particular vessel, ranging from the simple single davit handling a 10-foot dinghy slung on a single span, usual in harbor tugs and similar craft, to the row of lifeboats on a modern liner handled by steam or electric hoisters, while on the larger war vessels nests of boats are stowed and operated by special electric driven boat cranes or large derrick booms.

Before an arrangement of boat handling appliances can be laid out the special requirements governing the particular case as to number and type of boats must be considered and also the kind of davit decided upon. As already stated the rules and regulations of the hailing country and the trade will determine the former. The kind of davit suitable if the vessel be in the ocean passenger trade is restricted to two or three varieties as shown by the arrangements in the figures, these consisting of the ordinary rotating davit, the Mallory type or the Welin quadrant davit, the latter being an excellent davit but of course slightly more costly than the others, the cheapest and most convenient where there is room to install being that known as the Mallory davit.

Rotating Davits. — This is the most common type of davit used on shipboard. The davit and method of installing are shown by Fig. 242, but, of course the heelstep and bearing are susceptible of many variations to suit individual cases or local conditions. The required diameter suitable for a given weight of boat may be calculated by the equation $W \times a = \frac{\pi}{32} D^3 f$; by transposing we get diameter,

$$D = \sqrt[3]{\frac{\left(\frac{Wa}{f}\right)}{\frac{\pi}{32}}},$$

* For these requirements see "Inspectors of Steam Vessels, U. S.," "Board of Trade Rules and Regulations."

ROTATING DAVIT.

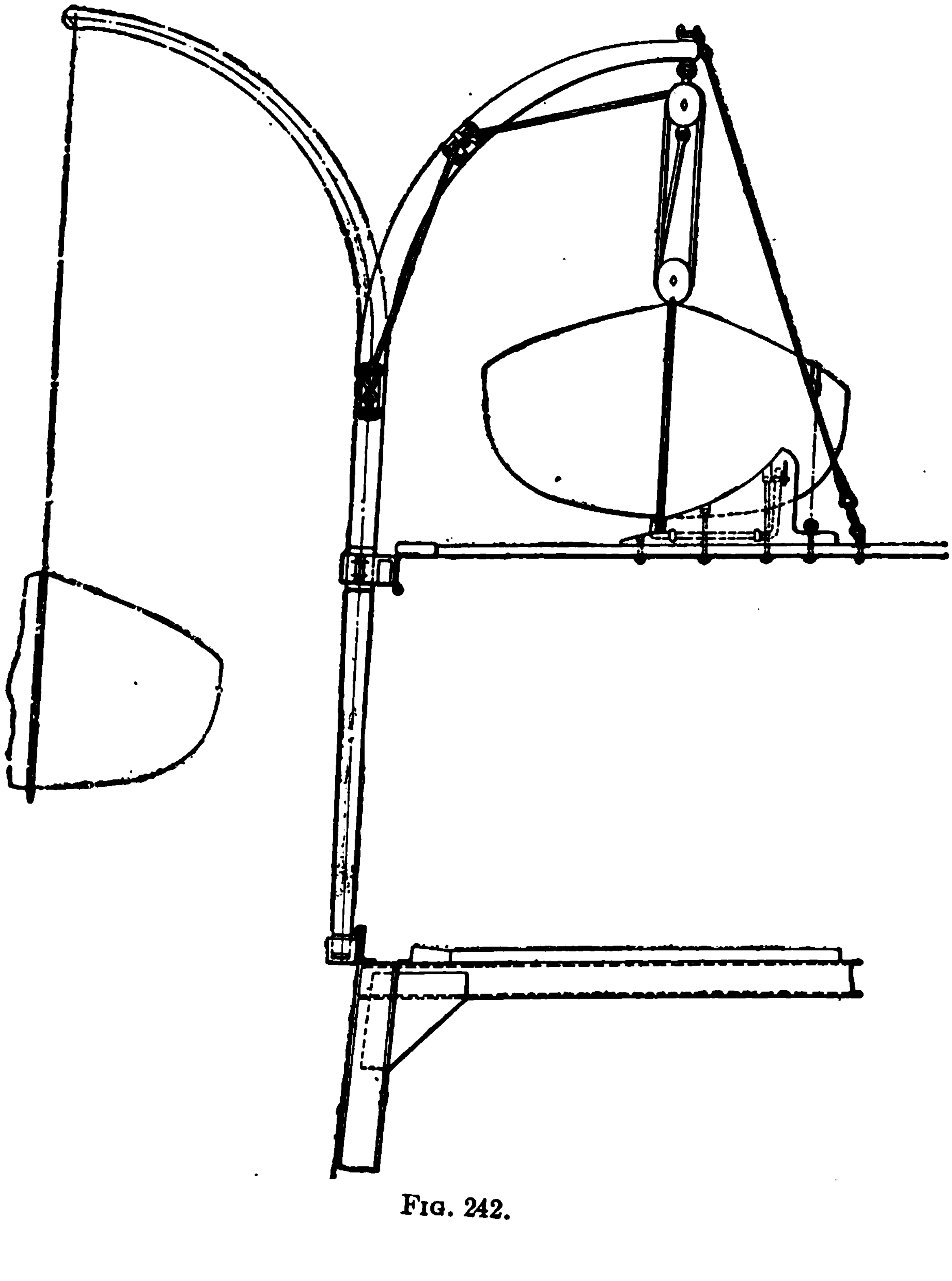


Fig. 242.

the lever a, or outreach of davit, being measured with the ship inclined 10 degrees. Where the ship is intended for Lloyd's classification the formula used as required by their Rules is practically similar to the foregoing, but is differently expressed to make it more convenient of application where actual weights of boats are not at hand and to ensure uniformity of requirements. Lloyd's formula is:

$$d = \sqrt[3]{\frac{L \times B \times D\,(H + 4S)}{C}},$$

where L, B and D are the length, breadth and depth respectively of the boat, H is the height of the davit above its uppermost point of support, and S is the spread of the davit; each of these dimensions being in feet.

The value of the constant term C is to be as follows: —

1. When the davit is to be of wrought iron and of sufficient strength to carry the boat, its equipment and a sufficient number of men to launch it, the value of C is to be 144.
2. When the davit referred to in (1) is to be of wrought ingot steel of from 28 to 32 tons per square inch tensile strength, the value of C is to be 174.
3. When the davit is to be of wrought iron and of sufficient strength to safely lower the boat fully equipped and carrying the maximum number of persons for which it is intended, the value of C is to be 82.
4. When the davit referred to in (3) is to be of wrought ingot steel of from 28 to 32 tons per square inch tensile strength, the value of C is to be 99.

The mountings on these davits comprise belay cleat, fairlead sheave, spectacles for span and guys, the span being clipped with sister hooks at one end and shackle on the other, and the guys shackled to spectacle and set up on deck with either lanyard or turnbuckle. On lifeboat davits, it is also obligatory to secure to davit head, lifelines of say 2-inch manila, long enough to reach to waterline and also a rope ladder from span. Where the davits operate the emergency boat (slung outboard at sea), a pudding boom should be lashed to davits suitably padded in wake of chafe to which the boat gripes are secured.

Suitable tackling for falls are readily determined from the weight of boat.*

In first class practice the cast-steel bearing is bushed with composition either gun metal or babbit and a conical disc of hard steel is inserted in the heelstep, these additions reducing the friction with a consequent acquisition to the ease of operation.

* For tackles see Knight's "Seamanship" or "The Naval Constructor."

MALLORY DAVIT.

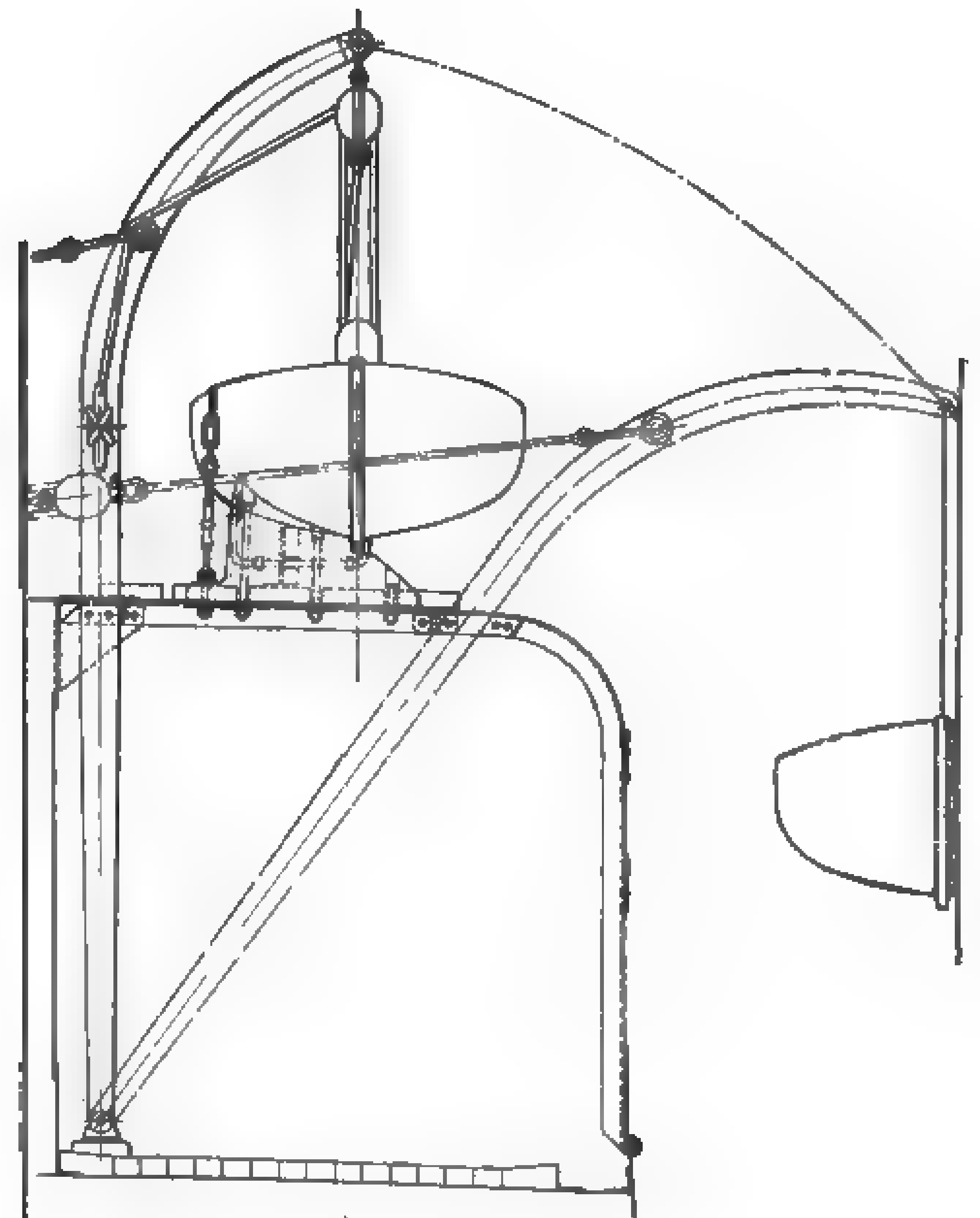


Fig. 243.

In the larger classes of war vessels, as battleships and cruisers, a variation of this davit is adopted having a pivoting bearing and a hinged clamp at heelstep to permit of turning down the davits when clearing the deck for action. The details of this type are various, observing that the bearing is cast in steel and bronze bushed, the swivel pin of wrot steel, and the step bearing of cast steel. A forged operating lever about four feet long is furnished for turning down the davit.

Mallory Davits. — These davits are not as common in practice as their many advantages would seem to warrant. They are not proprietory as the name might imply, the designating title being derived from the line of vessels in which they are most often fitted. A reference to Fig. 243 will show that they may be formed very simply from ordinary rectangular universal roll steel of a section at bearing step derived from the equation $W \times a = \frac{bh^2}{6} f$, as in the case of the swan-neck davits described on this page, the head and heel dimension being approximately two-thirds of the resulting b and h. Where boats are stowed overhead on skid beams adjoining deck houses Mallory davits are adaptable, take up very little room, and cost much less to install than the more common rotating davit, in addition to which they are much more quickly and conveniently operated. It will be seen that they hinge on a heel pin and move outboard between guides one of which may also be utilized as the skid beams and a positive stop inserted between them to limit the outboard range of the davit.

The boat, of course, is handled by the usual falls, but the davits are operated by tackles, the maximum pull on which will be $\frac{\frac{W}{2} a}{l}$, and the load on the handling part will equal this pull divided by the number of parts in the purchase.

Swan-neck Davits. — These davits, illustrated by Fig. 244, are mostly adopted for torpedo boat destroyers and similar craft on account of their lightness and their adaptability to the restricted deck area associated with this class of vessel as well as on account of their speed and ease of operation. It will be noted that the boat when stowed in these davits is entirely within the ship's deck line and that no actual deck space is occupied as the boat is carried overhead and securely griped to the davits and no part of the handling gear obtrudes itself beyond the side of ship. A reference to the figure will show that a comparatively small overhang is necessary to lower the boat overboard.

SWAN-NECK DAVIT.

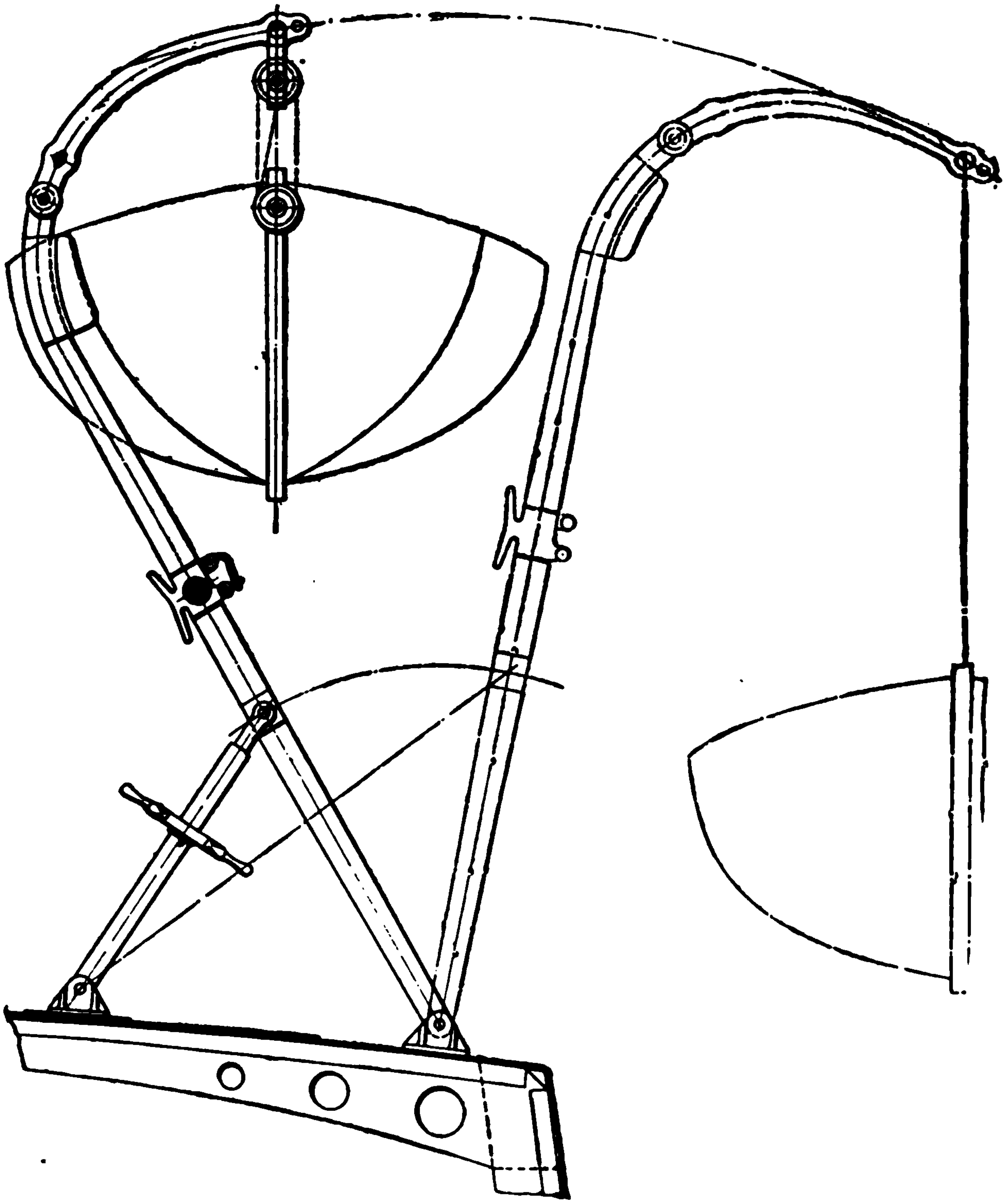


FIG. 244.

Davits of this type are usually made from universal roll rectangular steel bar although where extreme lightness is essential they may be worked from structural I section.

We shall assume, then, that the davits required are intended to handle a 23-foot whaleboat commonly carried on torpedo boat destroyers, and that the weight of boat plus two men is 1300 pounds + 300 pounds equal to a total load of 1600 pounds or 800 pounds per davit. It is sometimes erroneously assumed that one davit may be subjected to the entire load and the fibre stress increased to 15,000 pounds accordingly which of course is just the same as the more correct assumption of dividing the load between the davits and assuming a fibre stress of 7500 per square inch as we have done in the calculation.

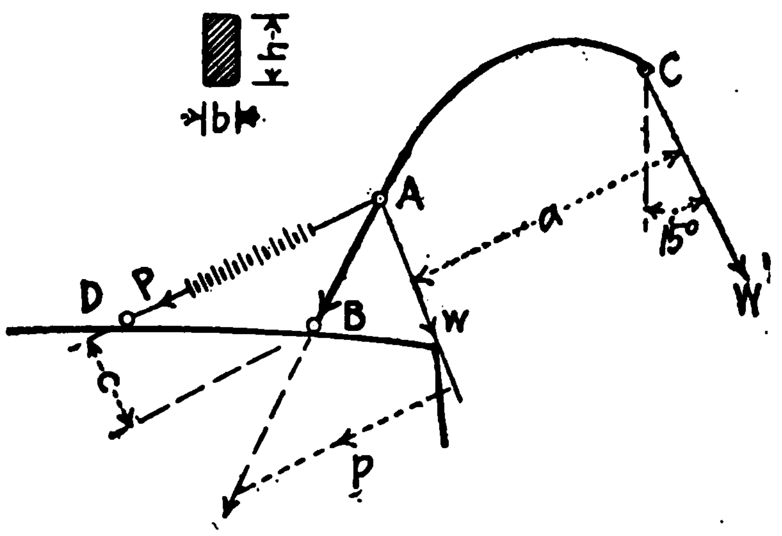


FIG. 245.

To determine the section of the davit we have to take the bending moment at A, where the greatest stress comes, with the ship, say 15 degrees, heeled over. Let us assume $b = 2\frac{1}{4}$ inches.

To find h we have

$$W \times a = P \times c = f\frac{bh^2}{6},$$

where

$$W = \frac{1600}{2} = 800 \text{ pounds},$$

$$a = 66 \text{ inches},$$

$$c = 27 \text{ inches},$$

$$b = 2\tfrac{1}{4} \text{ inches}.$$

In this case we will set the fibre stress at a low figure, say 7500 pounds per square inch, allowing a high factor of safety.

MINE DAVIT.

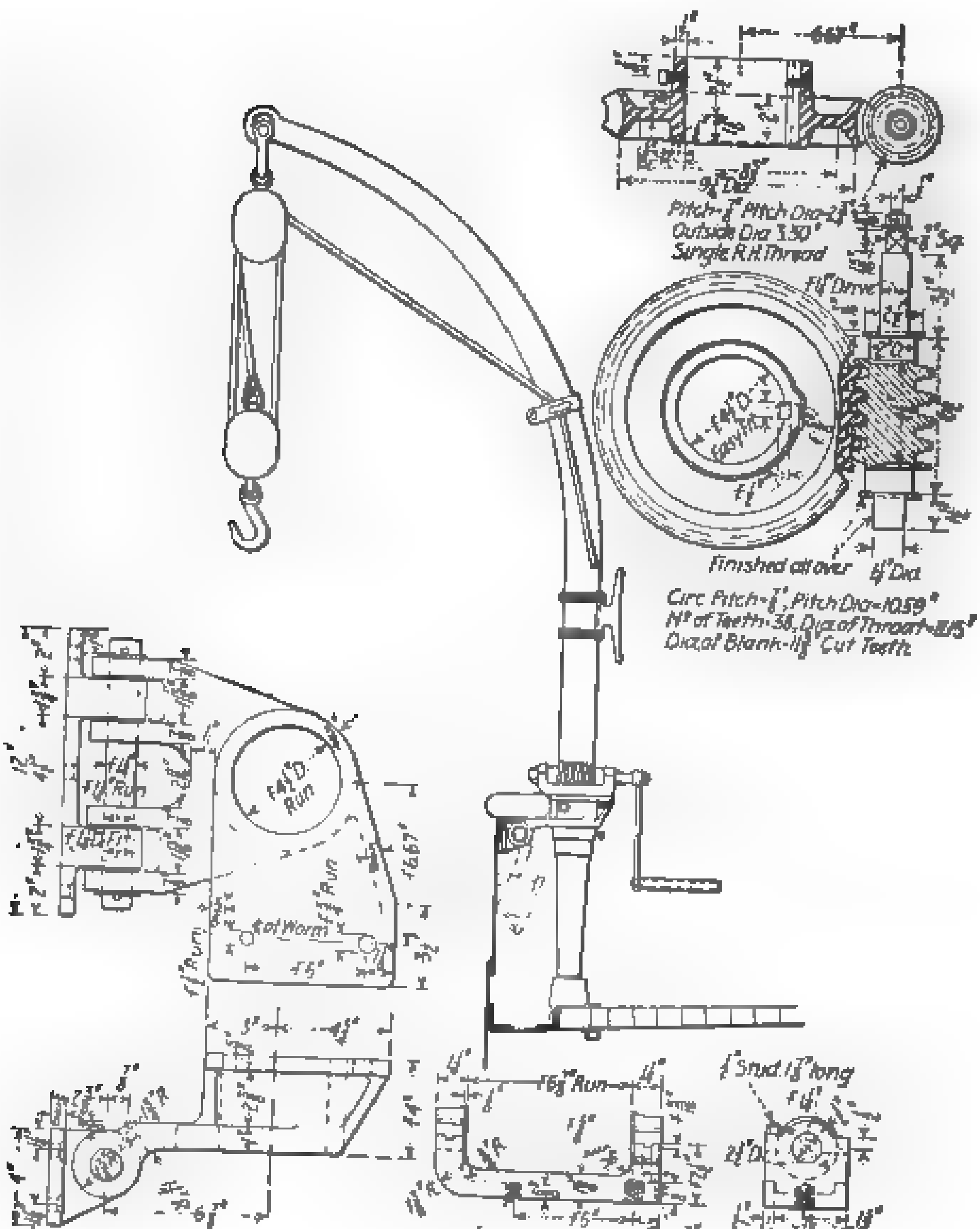


FIG. 246.

Then:

$$\frac{1600}{2} \times 66 = 7500 \frac{2.25\,h^2}{6},$$

and

$$h = \sqrt{\frac{800 \times 66 \times 6}{7500 \times 2.25}} = 4.33 \sim 4\tfrac{3}{8} \text{ inches.}$$

For P we have:

$$W \times a = P \times c, \quad \text{or} \quad 800 \times 66 = P \times 27,$$

where

$$P = \frac{800 \times 66}{27} = 1956 \text{ pounds.}$$

To determine the diameter at bottom of operating screw threads it would seem reasonable to derive this from the pull P with a fibre stress of 7500 pounds per square inch, or,

$$P = f\frac{\pi d^2}{4},$$

where

$$P = 1956 \text{ pounds,}$$
$$f = 7500 \text{ pounds,}$$

where

$$\frac{d^2}{4} = \frac{1950}{7500} = 0.26,$$

and

$$d = 0.58 \text{ inch.}$$

This, however, ignores the possibility of the screw being subjected to a bending stress or a combination of bending and compressive stresses caused by the movement of the vessel swaying the load. As the intensity of these is problematical we can only take care of it by using good judgment in selecting a suitable diameter. In the present case $1\frac{1}{2}$-inch diameter over the threads should provide an ample margin.

The thrust R on pin at B is more easily determined graphically as indicated in Fig. 1. In our case we get

$$R = 3786 \text{ pounds.}$$

The section of the davit should be gradually tapered down from A towards B and C. It is good practice to make the section near head C about two-thirds of the section at A. For larger davits it is desirable to figure the strength at different sections along the davit in order to make it as light as possible.

Pins at A, B, and D should always be figured for bending to

insure proper strength. In many cases, especially in smaller davits of this kind as illustrated here, it will be found that the diameter of pin thus figured is too small to be practicable and should, therefore, be increased properly.

Besides the athwartship screw-arm stay, an additional fore and aft stay is fitted to each davit to steady it and also to provide support against collapsing through the minor axis (especially for davits of rectangular section); this latter eventuality, however, is not likely to occur with davits of such small sizes as generally fabricated in this type.

Where occasion suggests it, it may be well to check for compression by Euler's formula:

$$P = \frac{2}{4\,f}\,\frac{EI}{l^2},$$

where

$P = W =$ load in pounds,

$E =$ modulus of elasticity,

$I =$ moment of inertia of section,

$l =$ vertical (projected on the load line) length of davit in inches.

f should in every case provide a sufficiently large factor of safety.

As the illustration shows, the davits are tied longitudinally by wire rope span and stay to the deck, a turnbuckle being fitted to set up.

Screw Gear. — With $d = 1\frac{1}{2}$ inches. For square threads the following proportions are generally adopted: —

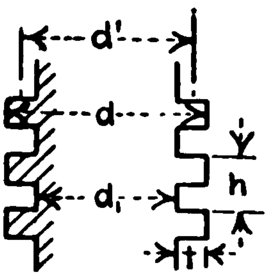


Fig. 247.

$$h \gtreqless \frac{d}{4}, \text{ say in this case}$$

$$h = \frac{5''}{16}; \quad t \gtreqless \frac{h}{2}, \text{ say } \frac{5''}{32}.$$

To find the power P necessary to turn the handwheel, we have:

$$P \times r = Q \times \frac{d^1}{2},$$

where $r =$ radius of handwheel,

in this case $= 7''$, $d^1 = 1\frac{11''}{32} = 1.34375''.$

WELIN DAVIT.

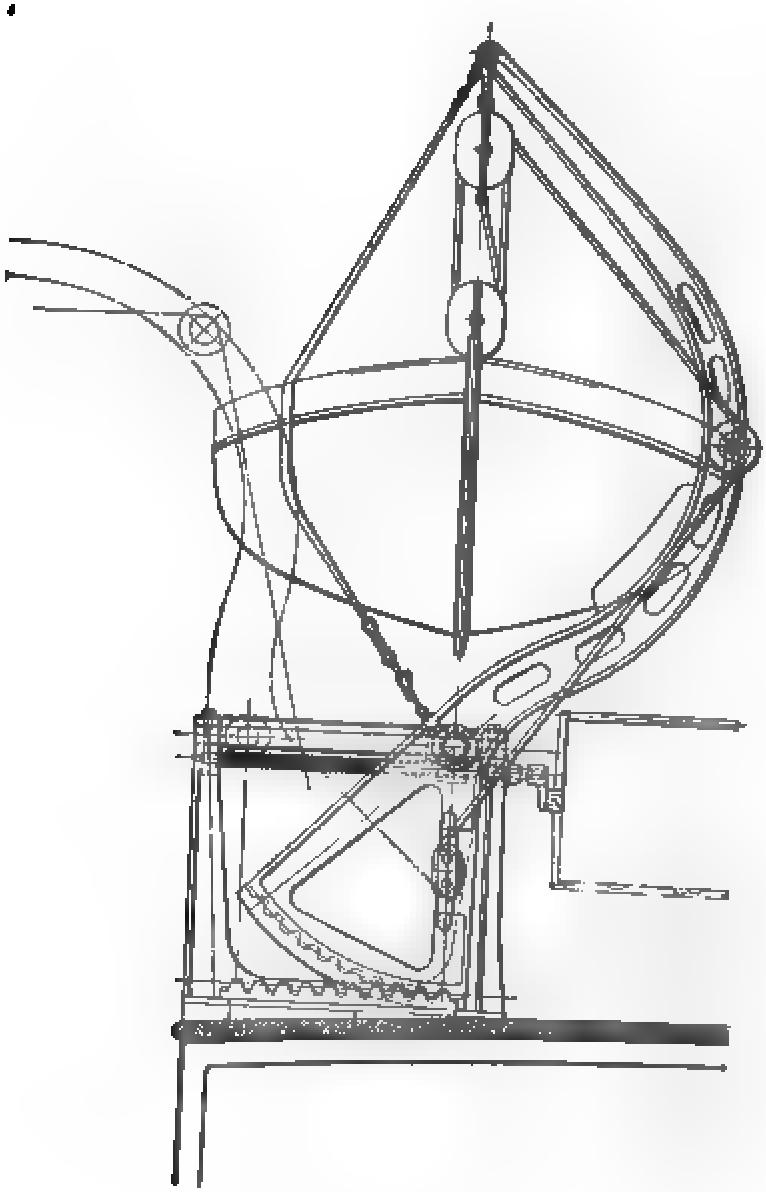


FIG. 248.

To find Q we have:

$$Q = W \frac{h + 2\pi \frac{d^1}{2} \mu}{2\pi \frac{d^1}{2} - h\mu},$$

where W = 1956 pounds (see above),

$h = \frac{5}{16}$-inch = 0.3125,

$\frac{d^1}{2}$ = 0.671875 inch,

μ = friction — coefficient,

in this case = abt. 0.1.

Then:

$$Q = 1956 \frac{0.3125 + 6.28 \times 0.672 \times 0.1}{6.28 \times 0.672 - 0.3125 \times 0.1} = 343 \text{ pounds}$$

and

$$P = \frac{Q \times \frac{d^1}{2}}{r} = \frac{343 \times 0.672}{7} = 33 \text{ pounds.}$$

As handwheels usually are operated by both hands each hand would exert

$$\frac{33}{2} = 16\tfrac{1}{2} \text{ pounds.}$$

Mountings. — The mountings or fittings on these davits comprise the span and stays previously mentioned of $1\frac{1}{2}$-inch circ. galvanized steel or iron wire rope with turnbuckle and eye-bolts through the neutral axis of davit section for securing, and lashing pad eyes, say $\frac{7}{16}$-inch wire by $1\frac{1}{4}$-inch to take setting up lanyards. One pair of blocks per davit either wood or iron suited to the size of falls rove in this case 6-inch iron blocks with phosphor bronze sheaves for $2\frac{1}{4}$-inch circ. manila and a $3\frac{3}{4}$-inch fairlead sheave of gun metal bolted through davit where shown. A combined belay pin and slip to release the sword matting gripe which is secured at top part to an eye in davit head and a chafing pad stuffed with oakum and covered with leather to protect the whaleboat.

BOARD OF TRADE RULES FOR ROUND DAVITS — SOLID AND HOLLOW.

In many cases the regulations require the davits to be of sufficient strength to safely lower the boats into the water, fully equipped and carrying the maximum number of persons for which they measure.

It will frequently happen that the same set of davits will be used for launching both open and decked lifeboats, and the diameter of the davits should be governed by the weight of the boat which imposes the greatest load on them when loaded with the maximum number of persons for which it measures.

The weights of the various types of boat should, therefore, be ascertained from time to time; and, in estimating the weight of the persons carried, an average of $1\frac{1}{4}$ cwts. (140 lbs.) should be allowed for each person.

The load on the davits includes the weight of the boat, equipments as specified in General Rules 8 and 9, maximum number of persons for which the boat measures by the rule, and blocks and falls. As the blocks are frequently made of metal and fitted with metal pulleys, their weight is considerable.

A wooden boat of section *A*, about 28 feet long, complete with equipments and gear as mentioned above and carrying 50 persons, is taken as imposing a load of 100 cwts. on the davits, or 2 cwts. per person for which the boat measures. This may be stated as follows: —

$$\frac{W}{N} = w, \qquad (1)$$

where W = total load on davits in cwts.;

N = maximum number of persons for which the boat measures;

w = load on davits in cwts. per person carried.

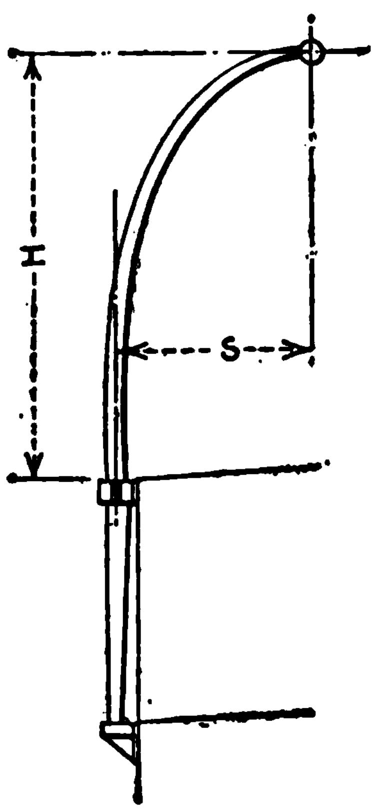


Fig. 249.

If the davits proposed are found to be equal in diameter to the dimensions obtained by the following rule (2), no objection need be raised, provided that, (*a*) the relative strength along the tapered parts is fully maintained, and (*b*) the total weight of the boat, equipments, maximum number of persons for which it measures, and blocks and falls does not exceed 2 cwts. per person, as ascertained by rule (1).

$$\sqrt[3]{\frac{L \times B \times D\,(H + 4\,S)}{C}} = d. \tag{2}$$

Where L = length of boat, in feet;

B = breadth of boat, in feet;

D = depth of boat, in feet;

H = height of davit, in feet, above upper support;

S = span of davit, in feet;

C = constant, to be taken as 86 for iron davits, and 104 for solid ingot steel davits of from 27 to 32 tons tensile strength, and for hollow welded davits of from 26 to 30 tons tensile strength;

d = diameter, in inches, of solid davit.

In dealing with hollow davits the equivalent sections may be found by the usual formula after the cube of the required diameter of solid davit has been ascertained by rule (2), as follows: —

$$d^3 = \frac{D_h^4 - D_h^4}{D_h}, \tag{3}$$

or

$$d_h = \sqrt[3]{\left(\frac{d^3 \times m^4}{m^4 - 1}\right)}. \tag{4}$$

Where d = diameter, in inches, of solid davit;

D_h = outside diameter, in inches, of hollow davit;

d_h = inside diameter, in inches, of hollow davit;

m = the ratio $\frac{D_h}{d_h}$.

Boats vary considerably in weight, small ones being relatively heavier than large ones, and weldless steel ones heavier than wooden ones, and a modification of the constant C, rule (2), will sometimes be required. This can easily be made when the maximum weight to be imposed on the davits is known and the quantity w has been found by rule (1). In the case of weldless steel boats w may be about 2.1 cwts., in which case the modification of the constant C in rule (2) will be: —

$$\frac{C \times 2}{2.1} = \text{modified constant.}$$

In the case of solid iron davits, the constant, modified as above, will be. —

$$\frac{86 \times 2}{2.1} = 82,$$

and for steel davits

$$\frac{104 \times 2}{2.1} = 99.$$

Formula (2) applies to boats of sections *A*, *B*, or *D*, in which the entire cubic capacity is measured for the persons carried, the constant *C* being reduced or increased as *w* is shown to be greater or less than 2 cwts. It also applies to boats of section *C* when the weight of the boat, equipments, and persons allowed,

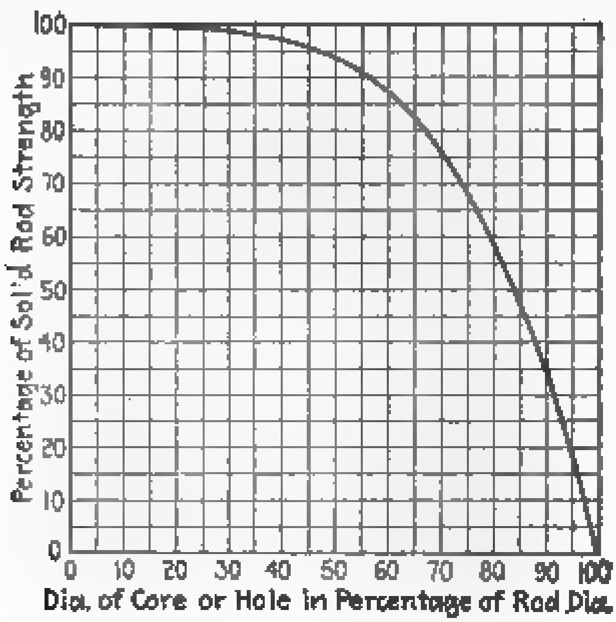


Fig. 250.

does not exceed that of an ordinary wooden boat of similar size of Section *A*, *B*, or *D*.

In the case of davits which are only required to be strong enough to carry the boat and equipments and a sufficient number of men to launch it, no objection need be raised if the diameter is not less than that found by formula (2), but using a constant, *C*, of 144 for davits of untested material.

The constants given for steel davits are on the understanding that the material is tested and found to be within the limits given.

DAVIT HEADS.

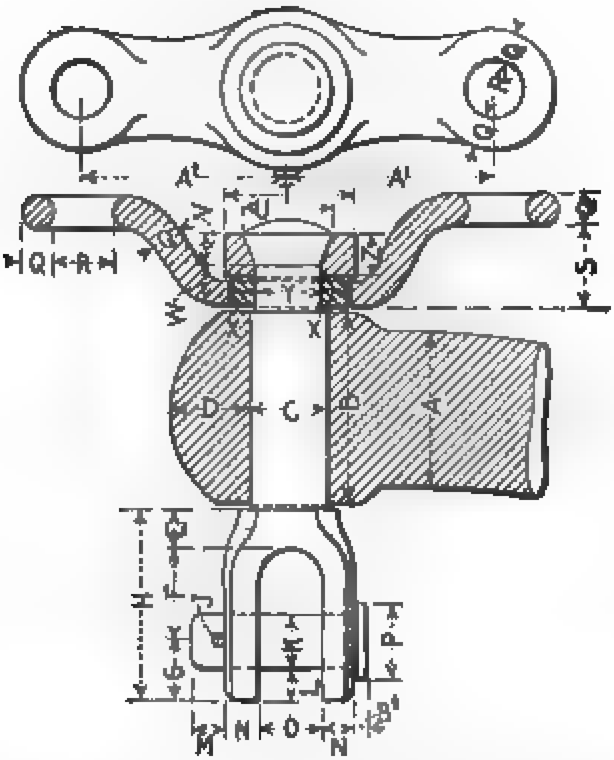


FIG. 251

Tons.	A	B	C	D	E	F	G	H	J	K	L	M	N
	"	"	"	"	"	"	"	"	"	"	"	"	"
0 9	1 3/4	2 1/8	7/8	7/8	3/8	1 1/8	1 9/16	2 5/16	5/16	5/8	1/2	1/2	1/2
1 2	2	2 1/2	1	1	7/16	1 1/4	7/8	2 9/16	3/16	3/4	1/2	1/2	1/2
1 5	2 1/4	2 3/4	1 1/8	1 1/8	1/2	1 3/8	1	2 7/8	3/16	13/16	9/16	1/2	9/16
1 7	2 1/2	3 1/8	1 1/4	1 1/4	9/16	1 1/2	1 1/16	3 1/8	3/16	7/8	9/16	1/2	9/16
1 9	2 3/4	3 3/8	1 3/8	1 3/8	5/8	1 5/8	1 1/16	3 5/16	1/4	1 3/16	5/8	5/8	5/8
2 3	3	3 3/4	1 1/2	1 1/2	5/8	1 3/4	1 3/16	3 11/16	1/4	1	11/16	5/8	11/16
2 8	3 1/4	4	1 5/8	1 5/8	7/8	2	1 3/8	4 1/4	1/4	1 1/8	3/4	5/8	3/4
3 3	3 1/2	4 3/8	1 3/4	1 3/4	1	2 1/4	1 1/2	4 3/4	1/4	1 1/4	7/8	5/8	13/16

Tons.	O	P	Q	R	S	T	U	V	W	X	Y	Z	A 1	B 1
—	"	"	"	"	"	"	"	"	"	"	"	"	"	"
0.9	3/4	7/8	3/8	1	1	1 1/2	1 3/8	3/8	1/2	1/4	3/4	1/2	2 5/8	5/16
1.2	7/8	1	3/8	1	1 1/4	1 3/4	1 5/16	7/16	9/16	5/16	7/8	5/8	3	3/16
1 5	15/16	1 1/8	7/16	1	1 3/8	2	1 1/2	7/16	3/8	5/16	1	11/16	3 1/4	5/16
1.7	1	1 1/4	1/2	1	1 1/2	2 1/8	1 5/8	1/2	3/4	3/8	1 1/16	3/4	3 3/8	1/4
1 9	1 1/16	1 3/8	9/16	1 1/8	1 1/2	2 1/4	1 11/16	9/16	13/16	3/8	1 1/8	3/4	3 5/8	1/4
2 3	1 1/8	1 1/2	5/8	1 1/8	1 5/8	2 1/2	1 7/8	5/8	7/8	7/16	1 1/4	13/16	3 7/8	1/4
2 8	1 1/4	1 5/8	11/16	1 1/4	1 3/4	2 3/4	2	11/16	15/16	7/16	1 3/8	7/8	4 1/8	1/4
3.3	1 3/8	1 7/8	3/4	1 3/8	1 3/4	3	2 1/4	3/4	1	1/2	1 1/2	15/16	4 3/8	5/16

WEIGHTS OF BOATS AND DAVIT DIAMETERS.

$$\text{Diameter} = \sqrt[3]{\frac{\left(\frac{Wl}{k}\right)}{\frac{\pi}{32}}}.$$

Dimensions of Boats. L. ′	B. ′	B. ″	D. ′	D. ″	Lifting Weight in Lbs.	Approximate Davit Radius ′	″	Diameter of Davit in Ins ″	Build of Boat.	Description.
10	4	3	1	7	670	3	2	$2\frac{1}{4}$	Wood clench	Dinghy.
12	4	6	1	9	900	3	4	$2\frac{3}{4}$	" "	"
14	4	8	1	11	1,120	3	6	3	" "	"
16	4	10	2	0	1,350	3	8	$3\frac{1}{4}$	" "	"
18	5	0	2	$0\frac{1}{2}$	1,550	3	9	$3\frac{1}{2}$	" "	Cutter.
20	5	4	2	2	1,800	4	0	4	" "	"
20	5	10	2	4	2,000	4	4	$4\frac{1}{4}$	" carvel	Yacht's launch.
22	5	10	2	4	2,240	4	4	$4\frac{1}{2}$	" clench	Cutter.
22	6	0	2	4	2,450	4	6	$4\frac{1}{2}$	" carvel	Yacht's launch.
24	7	3	3	0	2,450	5	6	$4\frac{3}{4}$	" clench	Lifeboat.
24	6	0	2	9	2,800	4	6	$4\frac{3}{4}$	" carvel	Yacht's launch.
26	7	6	3	3	2,700	5	7	$5\frac{1}{4}$	" clench	Lifeboat.
27	5	9	3	0	6,600	4	4	$5\frac{3}{4}$	" diagonal	Steam pinnace.
28	8	6	3	8	2,900	6	4	$5\frac{1}{2}$	" clench	Lifeboat.
30	8	6	3	8	3,000	6	4	6	" "	Lifeboat.
30	7	0	3	10	7,600	5	3	$7\frac{1}{4}$	" diagonal	Steam navy pinnace.
32	7	4	4	0	7,850	5	6	$7\frac{3}{4}$	" "	" " "
36	8	0	4	3	13,500	6	0	9	" "	" " "
40	8	6	4	9	18,500	6	4	8 (3)	" "	" " "
42	8	2	4	6	14,000	6	2	$7\frac{1}{2}$ (3)	" "	Royal barge.
45	8	6	4	6	21,300	6	4	$8\frac{1}{4}$ (3)	" "	Steam navy pinnace.
47	9	0	4	6	22,400	6	9	9 (3)	" "	" " "
50	9	3	5	8	23,500	7	0	Crane	" "	" " "
56	9	9	4	10	27,500	7	4	Crane	" "	" " "
60	9	6	4	10	28,500	7	2	Crane	" "	" " "

These davit diameters are figured for the moment exerted with the ship inclined, and are taken for a fibre stress of 12,000 lbs. per square inch, with one davit taking the entire load.

NAVY STANDARD.

Hinged Watertight Doors.

SIZE OF OPENING IN THE CLEAR.	DIMENSIONS OVER DOOR FRAME.	BREADTH OF FRAME.
′ ″ ′ ″	′ ″ ′ ″	
5 6 × 3 0	6 1⅞ × 3 7	3½ inches each side and end with ⅞ inch extra on one side for hinge pads.
5 6 × 2 2	6 1⅞ × 2 9	
5 0 × 3 0	5 7⅞ × 3 7	
5 0 × 2 0	5 7⅞ × 2 7	
4 0 × 2 0	4 7⅞ × 2 7	
3 6 × 2 0	4 1⅞ × 2 7	
2 6 × 1 6	3 1⅞ × 2 1	

Sliding Watertight Doors.

′ ″ ′ ″	′ ″ ′ ″	
4 9 × 2 0	5 6½ × 2 8	4″ V.S.W.T.D.
3 3 × 2 0	4 0½ × 2 8	4″ V.S.W.T.D.

SLIDING WATERTIGHT DOOR.

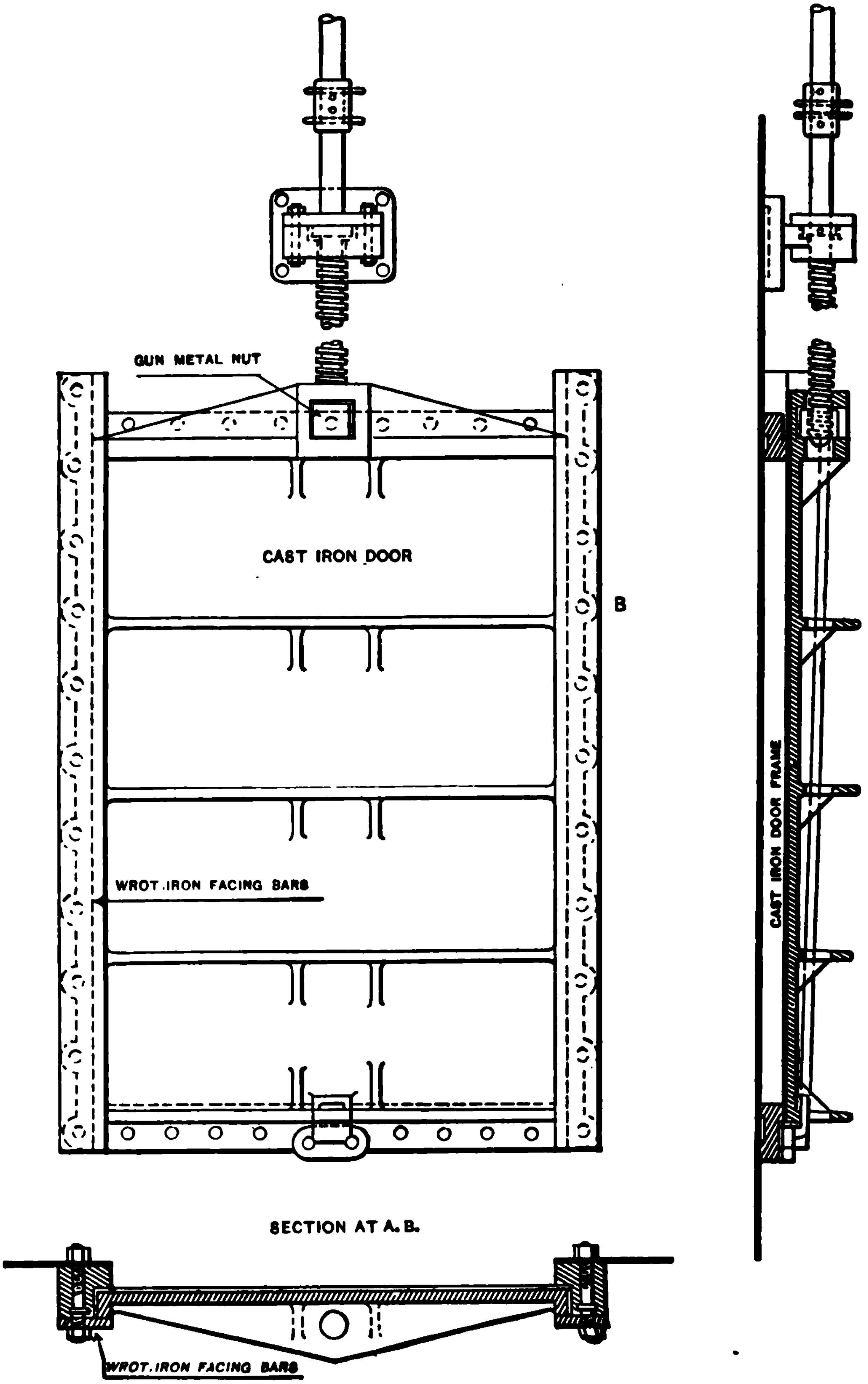


Fig. 252.

HINGED WATERTIGHT DOOR.

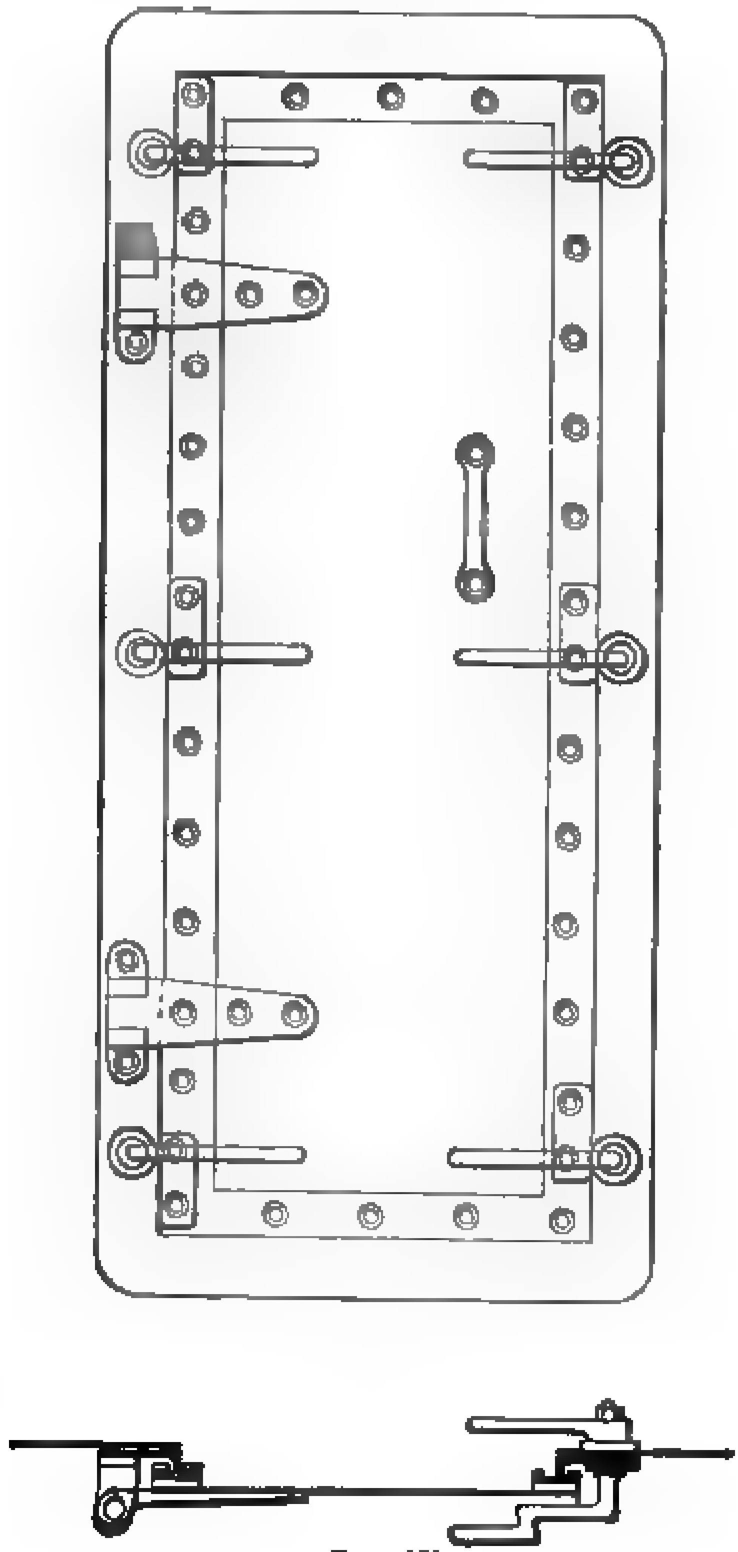
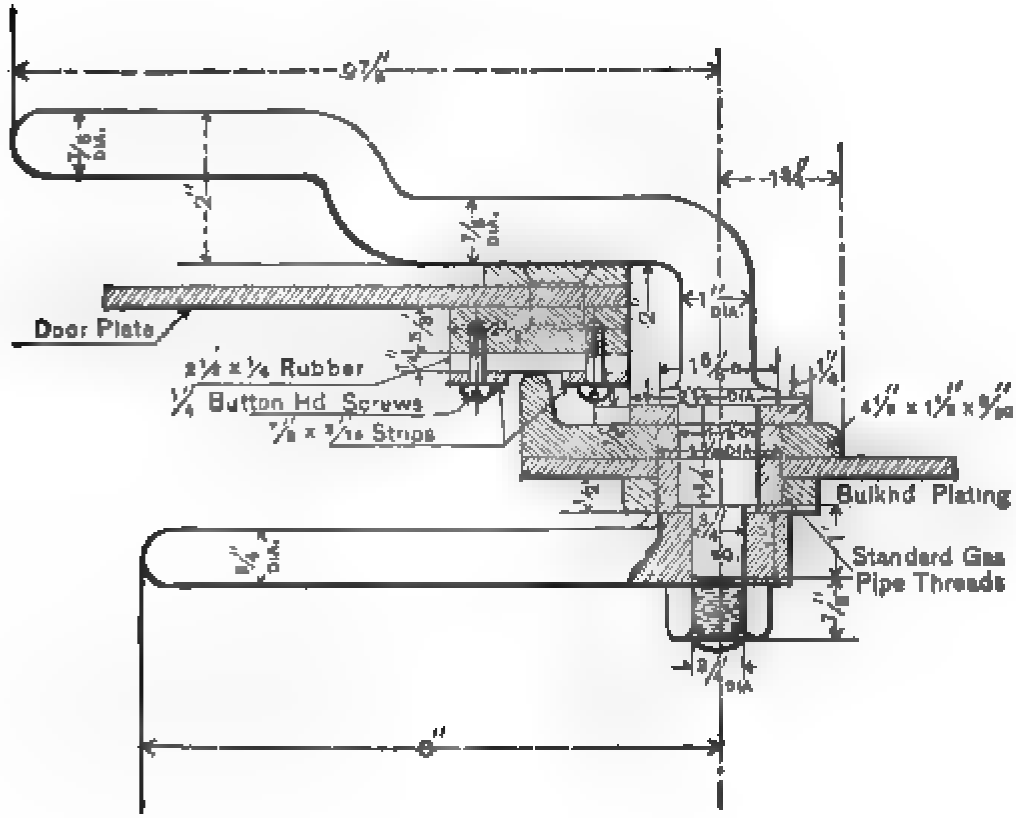
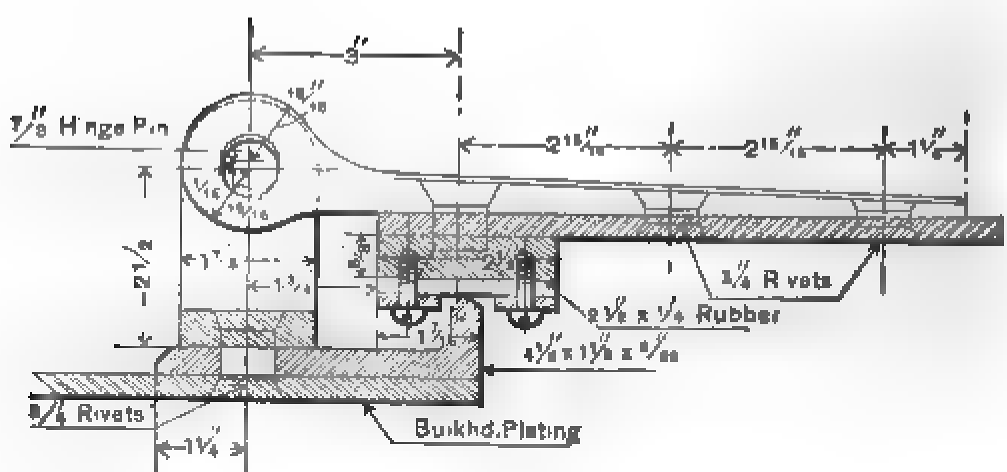


FIG. 253.



DETAIL OF DOGS
FIG. 254.



DETAIL OF HINGES
FIG. 255.

STANDARD EYEBOLTS.

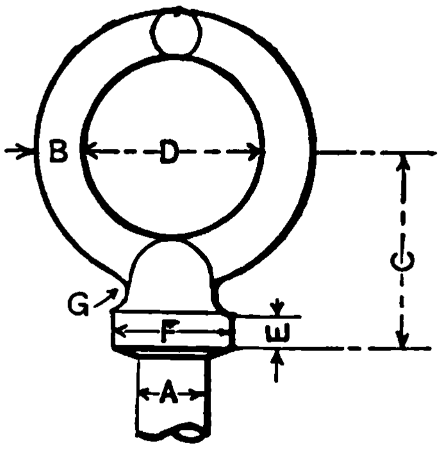


FIG. 256.

A.	B.	C.	D.	E.	F.	G.	Breaks at Tons.
$\frac{1}{4}$	$\frac{3}{16}$	$\frac{25}{32}$	$\frac{11}{16}$	$\frac{5}{32}$	$\frac{15}{32}$	$\frac{3}{16}$	$1\frac{3}{4}$
$\frac{3}{8}$	$\frac{9}{32}$	$1\frac{3}{32}$	1	$\frac{3}{16}$	$\frac{11}{16}$	$\frac{1}{4}$	$2\frac{1}{2}$
$\frac{7}{16}$	$\frac{21}{64}$	$1\frac{1}{4}$	$1\frac{3}{32}$	$\frac{13}{64}$	$\frac{25}{32}$	$\frac{9}{32}$	3
$\frac{1}{2}$	$\frac{3}{8}$	$1\frac{3}{8}$	$1\frac{3}{16}$	$\frac{7}{32}$	$\frac{7}{8}$	$\frac{5}{16}$	5
$\frac{5}{8}$	$\frac{15}{32}$	$1\frac{5}{8}$	$1\frac{3}{8}$	$\frac{1}{4}$	$1\frac{1}{16}$	$\frac{3}{8}$	6
$\frac{3}{4}$	$\frac{9}{16}$	$1\frac{13}{16}$	$1\frac{1}{2}$	$\frac{5}{16}$	$1\frac{1}{4}$	$\frac{7}{16}$	8
1	$\frac{3}{4}$	$2\frac{1}{4}$	$1\frac{13}{16}$	$\frac{13}{32}$	$1\frac{9}{16}$	$\frac{1}{2}$	22
$1\frac{1}{8}$	$\frac{13}{16}$	$2\frac{1}{2}$	2	$\frac{15}{32}$	$1\frac{11}{16}$	$\frac{9}{16}$	27
$1\frac{1}{4}$	$\frac{7}{8}$	$2\frac{3}{4}$	$2\frac{1}{8}$	$\frac{1}{2}$	$1\frac{7}{8}$	$\frac{5}{8}$	33
$1\frac{1}{2}$	$1\frac{1}{16}$	$3\frac{1}{8}$	$2\frac{7}{16}$	$\frac{9}{16}$	$2\frac{3}{16}$	$\frac{11}{16}$	40
$1\frac{3}{4}$	$1\frac{3}{16}$	$3\frac{5}{8}$	$2\frac{3}{4}$	$\frac{5}{8}$	$2\frac{1}{2}$	$\frac{3}{4}$	47
2	$1\frac{3}{8}$	$4\frac{3}{8}$	$3\frac{1}{4}$	$\frac{3}{4}$	$2\frac{7}{8}$	$\frac{13}{16}$	50

TABLE OF FAIRLEADS (Cast Iron).

SINGLE ROLLER.

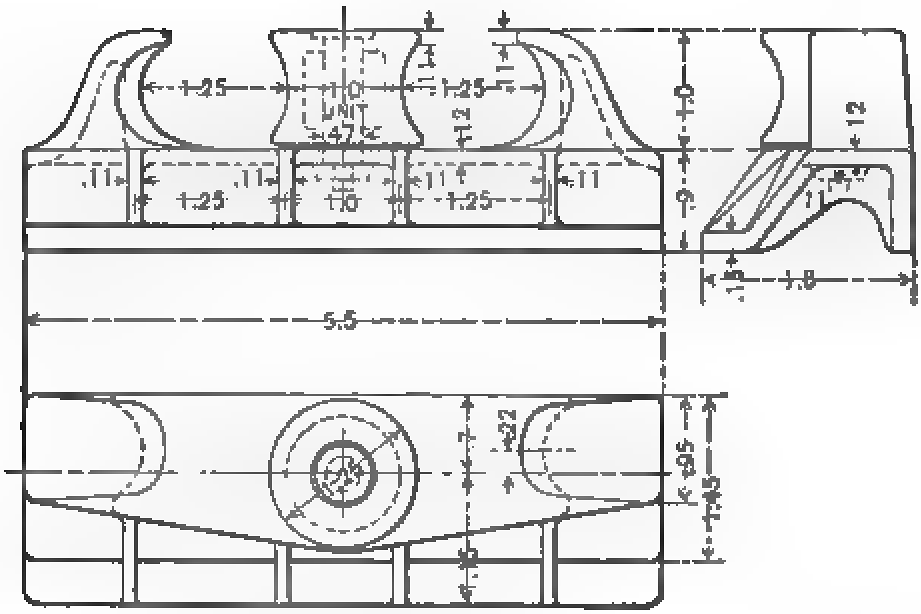
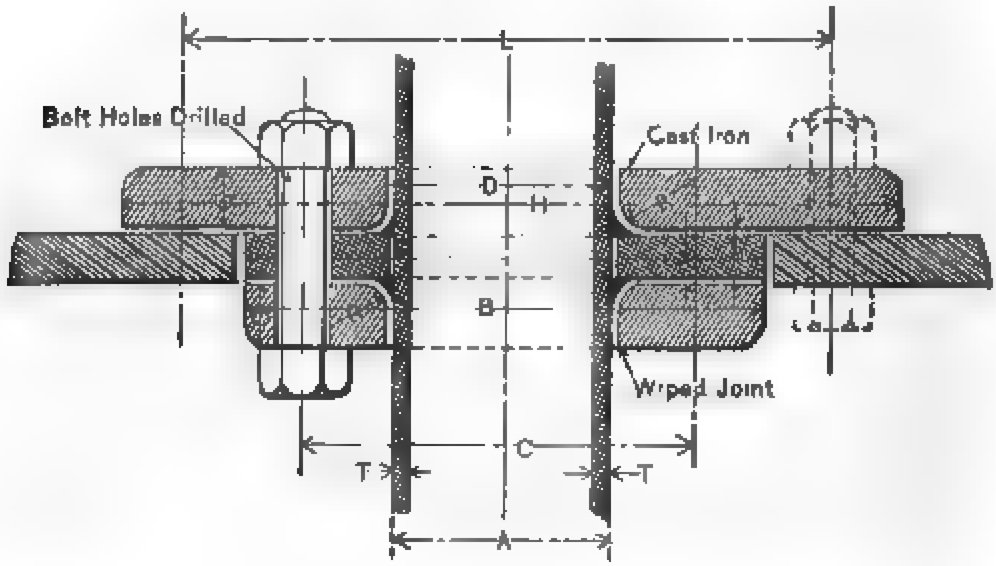


FIG. 257.

LENGTH OF SHIP (FT.)	UNIT DIMENSION IN INCHES. *d*.	APPROXIMATE WEIGHT IN POUNDS.	LENGTH OF SHIP (FT.).	UNIT DIMENSION IN INCHES. *d*.	APPROXIMATE WEIGHT IN POUNDS.
100	3	34	470	11	1,670
110	3½	[illegible]	490	11½	1,907
120	4	80	520	12	2,167
150	4½	115	550	12½	2,450
170	5	156	570	13	2,750
190	5½	208	600	13½	3,085
200	6	271	620	14	3,436
215	6½	[illegible]	650	14½	3,820
240	7	[illegible]	680	15	4,230
280	7½	530	710	15½	4,670
300	8	644	740	16	5,140
330	8½	770	760	16½	5,635
360	9	915	780	17	6,165
390	9½	1,073	800	17½	6,720
410	10	1,253	850	18	7,315
440	10½	1,452	....	....	.....

Weight without roller $= d^3 \times .6 =$ lbs.
Weight with one roller $= d^3 \times 1.25$.
Weight with two rollers $= d^3 \times 1.5$.

STANDARD FLANGES FOR LEAD PIPES.



NOTE: NO FINISH ON CAST IRON FLANGES

FIG. 258.

FROM 0 TO 100 POUNDS PRESSURE.													
Size of Valve Used.	*A.*	*B.*	*C.*	*D.*	*G.*	*H*	*L.*	*R.*	*S*	*T*	No Bolts for Bulkhead Flange	No. for Standard Flange.	Size of Bolts.
2	$2\frac{1}{2}$	$6\frac{1}{4}$	$4\frac{1}{2}$	$2\frac{3}{4}$	$\frac{7}{8}$	$9\frac{3}{4}$	8	$\frac{5}{8}$	$\frac{1}{4}$	$\frac{1}{4}$	6	4	$\frac{5}{8}$
$2\frac{1}{2}$	3	7	$5\frac{1}{4}$	$3\frac{1}{4}$	$\frac{7}{8}$	$10\frac{1}{2}$	$8\frac{3}{4}$	$\frac{3}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	8	5	$\frac{5}{8}$
3	$3\frac{1}{2}$	$7\frac{1}{2}$	$5\frac{3}{4}$	$3\frac{3}{4}$	1	11	$9\frac{1}{4}$	$\frac{3}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	8	5	$\frac{5}{8}$
$3\frac{1}{2}$	4	$8\frac{1}{8}$	$6\frac{3}{8}$	$4\frac{1}{4}$	1	$11\frac{5}{8}$	$9\frac{7}{8}$	$\frac{3}{4}$	$\frac{3}{8}$	$\frac{1}{4}$	8	6	$\frac{5}{8}$
4	$4\frac{5}{8}$	9	7	$4\frac{7}{8}$	$1\frac{1}{8}$	13	11	$\frac{7}{8}$	$\frac{3}{8}$	$\frac{5}{16}$	8	6	$\frac{3}{4}$
$4\frac{1}{2}$	$5\frac{1}{8}$	$9\frac{3}{4}$	$7\frac{3}{4}$	$5\frac{3}{8}$	$1\frac{1}{8}$	$13\frac{3}{4}$	$11\frac{3}{4}$	$\frac{7}{8}$	$\frac{7}{16}$	$\frac{5}{16}$	8	6	$\frac{3}{4}$
5	$5\frac{5}{8}$	$10\frac{1}{4}$	$8\frac{1}{4}$	$5\frac{7}{8}$	$1\frac{1}{4}$	$14\frac{1}{4}$	$12\frac{1}{4}$	1	$\frac{1}{2}$	$\frac{5}{16}$	8	6	$\frac{3}{4}$
$5\frac{1}{2}$	$6\frac{1}{8}$	$10\frac{3}{4}$	$8\frac{3}{4}$	$6\frac{3}{8}$	$1\frac{1}{4}$	$14\frac{3}{4}$	$12\frac{3}{4}$	1	$\frac{1}{2}$	$\frac{5}{16}$	10	7	$\frac{3}{4}$
6	$6\frac{3}{4}$	$11\frac{1}{4}$	$9\frac{1}{2}$	7	$1\frac{3}{8}$	$15\frac{1}{2}$	$13\frac{1}{2}$	1	$\frac{1}{2}$	$\frac{5}{16}$	10	7	$\frac{3}{4}$

PIPE FLANGES, STANDARD.

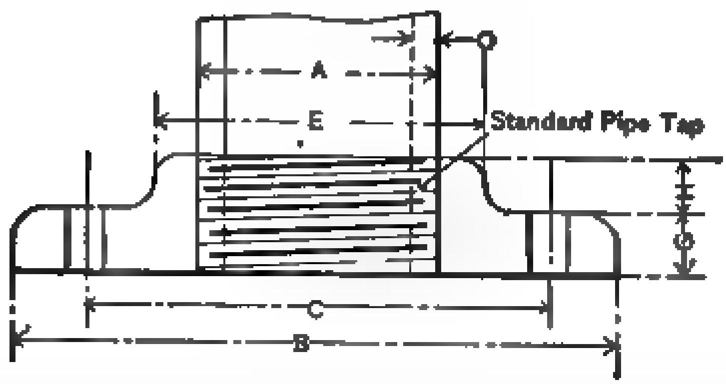
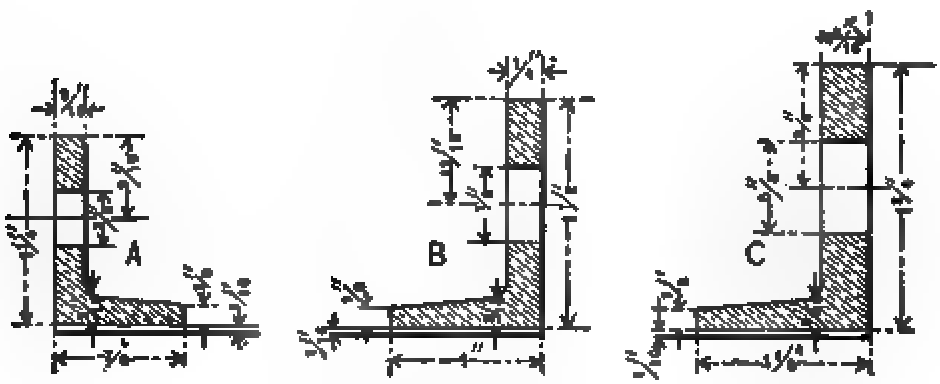


FIG. 269.

Size of Valve used in Connection with Pipe.	From 0 to 100 Pounds Pressure per Square Inch.										
	Nom. Internal Diameter of Pipe.	Outside Dia. of Pipe. A.	Diameter of Flange. B.	Diameter of Bolt Circle. C.	Diameter of Boss E.	Thickness of Flange. G.	Height of Boss. H.	Thickness of Pipe. O.	Number of Threads per Inch.	Diameter of Steel Bolts.	Number of Bolts.
"	"	"	"	"	"	"	"	"		"	
½	½	.840	3½	2⅜	1¼	7/16	⅛	.109	14	½	3
¾	¾	1.050	4	2⅝	1½	½	⅛	.113	14	½	3
1	1	1 315	4⅞	3¼	1¾	½	¼	.134	11½	½	3
1¼	1¼	1.660	5⅜	3½	2⅛	½	¼	.140	11½	⅝	3
1½	1½	1.900	5½	3⅞	2⅜	9/16	¼	.145	11½	⅝	4
2	2	2.375	6¼	4½	3	⅝	¼	.154	11½	⅝	4
2½	2½	2 875	7	5¼	3⅝	¾	¼	.204	8	⅝	5
3	3	3.50	7½	5¾	4¼	¾	¼	.217	8	⅝	5
3½	3½	4 00	8½	6⅜	4¾	13/16	5/16	.226	8	⅝	6
4	4	4 50	9	7	5¼	⅞	⅜	.237	8	⅝	6
4½	4½	5 00	9¼	7¾	6	⅞	½	.246	8	¾	6
5	5	5 563	10¼	8¼	6½	⅞	⅝	.259	8	¾	6
6	6	6.625	11½	9½	7¾	1	⅝	.280	[illegible]	¾	7

STANDARD FLANGES FOR VENTILATION.



FIGS. 260 TO 262.

A.				B.				C.			
Inside Diameter of		Bolts.		Inside Diameter of		Bolts.		Inside Diameter of		Bolts.	
Pipe.	Flange.	No.	Size	Pipe.	Flange	No.	Size	Pipe.	Flange.	No.	Size.
"	"		"	"	"		"	"	"		"
2	2[illegible]	3	[illegible]	8½	8[illegible]	8	[illegible]	16½	16[illegible]	11	[illegible]
2½	2[illegible]	4	[illegible]	9	9[illegible]	8	[illegible]	17	17[illegible]	12	[illegible]
2¾	2[illegible]	4	[illegible]	9½	9[illegible]	9	[illegible]	17½	17[illegible]	12	[illegible]
3	3[illegible]	4	[illegible]	10	10[illegible]	9	[illegible]	18	18[illegible]	12	[illegible]
3½	3[illegible]	5	[illegible]	10½	10[illegible]	9	[illegible]	18½	18[illegible]	13	[illegible]
4	4[illegible]	5	[illegible]	11	11[illegible]	10	[illegible]	19	19[illegible]	13	[illegible]
4½	4[illegible]	6	[illegible]	11½	11[illegible]	10	[illegible]	19½	19[illegible]	13	[illegible]
5	5[illegible]	7	[illegible]	12	12[illegible]	11	[illegible]	20	20[illegible]	14	[illegible]
5½	5[illegible]	7	[illegible]	12½	12[illegible]	11	[illegible]	20½	20[illegible]	14	[illegible]
6	6[illegible]	8	[illegible]	13	13[illegible]	11	[illegible]	21	21[illegible]	14	[illegible]
6½	6[illegible]	8	[illegible]	13½	13[illegible]	12	[illegible]	21½	21[illegible]	14	[illegible]
7	7[illegible]	9	[illegible]	14	14[illegible]	12	[illegible]	22	22[illegible]	15	[illegible]
7½	7[illegible]	9	[illegible]	14½	14[illegible]	12	[illegible]	22½	22[illegible]	15	[illegible]
8	8[illegible]	10	[illegible]	15	15[illegible]	13	[illegible]	23	23[illegible]	15	[illegible]
...	...	..	..	15½	15[illegible]	13	[illegible]	23½	23[illegible]	16	[illegible]
...	....	..	..	16	16[illegible]	14	[illegible]	24	24[illegible]	16	[illegible]

HAND WHEELS (Iron).

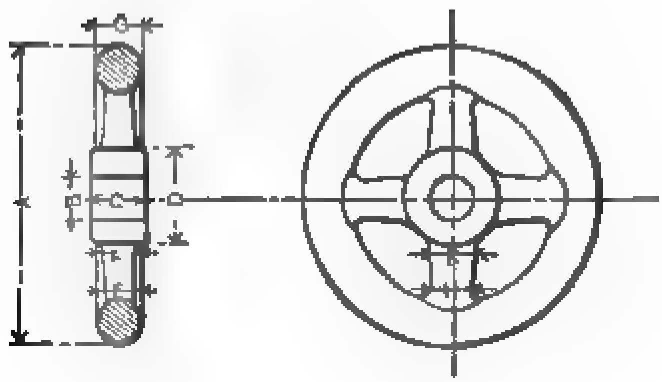


FIG. 263.

Diameter.									No. of Arms.
A.	B.	C.	D.	E.	F.	G.	H.	K.	
"	"	"	"	"	"	"	"	"	
2	. .	3/8	5/8	3/16	1/4	5/16	1/4	5/16	4
2 1/2	. .	7/16	3/4	3/16	1/4	3/8	5/16	3/8	4
3	. .	1/2	7/8	1/4	5/16	7/16	3/8	7/16	4
3 1/2	. .	5/8	1	1/4	5/16	1/2	7/16	1/2	4
4	. .	11/16	1 1/8	5/16	3/8	9/16	7/16	1/2	5
4 1/2	. .	3/4	1 1/4	5/16	7/16	5/8	1/2	9/16	5
5	. .	13/16	1 5/16	3/8	7/16	11/16	1/2	5/8	5
6	. .	7/8	1 3/8	3/8	1/2	3/4	9/16	11/16	6
7	. .	1	1 1/2	7/16	1/2	7/8	5/8	3/4	6
8	. .	1 1/16	1 11/16	7/16	1/2	15/16	11/16	13/16	6
9	. .	1 1/8	1 13/16	1/2	9/16	1	3/4	7/8	6
10	. .	1 3/16	1 7/8	1/2	5/8	1 1/16	13/16	15/16	6
12	. .	1 5/16	2 1/4	9/16	11/16	1 3/16	7/8	1 1/16	6
14	. .	1 1/2	2 9/16	5/8	3/4	1 3/8	1	1 3/16	6
16	. .	1 5/8	2 7/8	11/16	13/16	1 7/16	1 1/8	1 3/8	6
18	. .	1 3/4	3 1/8	3/4	7/8	1 9/16	1 1/4	1 1/2	6
21	. .	1 15/16	3 5/8	13/16	1	1 3/4	1 3/8	1 5/8	6
24	. .	2 1/8	4	7/8	1 1/16	1 7/8	1 1/2	1 7/8	6

HAND WHEELS (Brass).

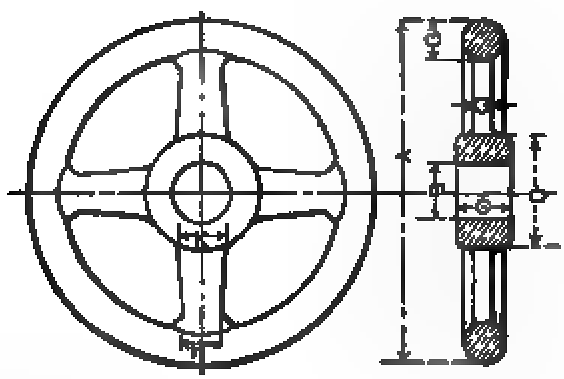


Fig. 264.

Diam., A.	B.	C.	D.	E.	G.	H.	K.	No. of Arms.
″	″	″	″	″	″	″	″	″
1½	. . .	5/16	9/16	1/8	1/4	3/16	1/4	4
2	. . .	3/8	5/8	1/8	1/4	1/4	5/16	4
2½	. . .	7/16	3/4	1/8	5/16	5/16	3/8	4
3	. . .	7/16	7/8	1/8	5/16	5/16	7/16	4
3½	. . .	1/2	1 1/8	3/16	3/8	3/8	1/2	4
4	. . .	1/2	1 3/16	3/16	3/8	3/8	9/16	4
4½	. . .	9/16	1 1/4	3/16	7/16	7/16	5/8	4
5	. . .	5/8	1 3/8	3/16	1/2	7/16	5/8	4
6	. . .	11/16	1 5/8	1/4	9/16	1/2	11/16	4
7	. . .	3/4	1 3/4	1/4	5/8	9/16	3/4	4
8	. . .	7/8	1 7/8	5/16	11/16	5/8	13/16	4
9	. . .	15/16	2	5/16	3/4	5/8	7/8	4
10	. . .	1	2	3/8	13/16	11/16	15/16	5
11	. . .	1 1/16	2 1/8	3/8	7/8	3/4	1	5
12	. . .	1 1/8	2 1/4	3/8	15/16	3/4	1 1/16	5
14	. . .	1 5/16	2 1/2	7/16	1 1/8	7/8	1 3/16	5
16	. . .	1 7/16	2 13/16	1/2	1 1/4	15/16	1 5/16	6
18	. . .	1 5/8	3 1/16	9/16	1 3/8	1 1/16	1 7/16	6
21	. . .	1 7/8	3 1/2	5/8	1 5/8	1 3/16	1 5/8	6
24	. . .	2 1/16	3 7/8	11/16	1 13/16	1 5/16	1 3/4	6

KEYS AND KEYWAYS.

D = diameter of shaft in inches.
W = width of key and keyway in inches,
$= \frac{3}{16} D + \frac{1}{8}$.
T = thickness of key $= \frac{3}{32} D + \frac{1}{8}''$.
Taper $= \frac{1}{8}''$ per foot.
t = depth in shaft } measured at the
$T - t$ = depth in hub } side.

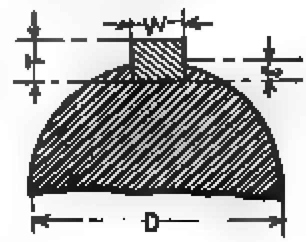


FIG. 265.

D.	W.	T.	t.	$T-t$	D.	W.	T.	t.	$T-t$.
"	"	"	"	"	"	"	"	"	"
$\frac{1}{2}$	$\frac{7}{32}$	$\frac{3}{16}$	$\frac{1}{16}$	$\frac{1}{8}$	5	$1\frac{1}{16}$	$\frac{5}{8}$	$\frac{1}{4}$	$\frac{3}{8}$
$\frac{5}{8}$	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{1}{16}$	$\frac{1}{8}$	$5\frac{1}{4}$	$1\frac{1}{8}$	$\frac{5}{8}$	$\frac{1}{4}$	$\frac{3}{8}$
$\frac{3}{4}$	$\frac{9}{32}$	$\frac{3}{16}$	$\frac{1}{16}$	$\frac{1}{8}$	$5\frac{1}{2}$	$1\frac{3}{16}$	$\frac{5}{8}$	$\frac{1}{4}$	$\frac{3}{8}$
$\frac{7}{8}$	$\frac{9}{32}$	$\frac{7}{32}$	$\frac{3}{32}$	$\frac{1}{8}$	$5\frac{3}{4}$	$1\frac{3}{16}$	$\frac{11}{16}$	$\frac{5}{16}$	$\frac{3}{8}$
1	$\frac{5}{16}$	$\frac{7}{32}$	$\frac{3}{32}$	$\frac{1}{8}$	6	$1\frac{1}{4}$	$\frac{11}{16}$	$\frac{5}{16}$	$\frac{3}{8}$
$1\frac{1}{8}$	$\frac{11}{32}$	$\frac{1}{4}$	$\frac{3}{32}$	$\frac{5}{32}$	$6\frac{1}{4}$	$1\frac{5}{16}$	$\frac{3}{4}$	$\frac{5}{16}$	$\frac{7}{16}$
$1\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{3}{32}$	$\frac{5}{32}$	$6\frac{1}{2}$	$1\frac{3}{8}$	$\frac{3}{4}$	$\frac{5}{16}$	$\frac{7}{16}$
$1\frac{3}{8}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{3}{32}$	$\frac{5}{32}$	$6\frac{3}{4}$	$1\frac{3}{8}$	$\frac{3}{4}$	$\frac{5}{16}$	$\frac{7}{16}$
$1\frac{1}{2}$	$\frac{13}{32}$	$\frac{1}{4}$	$\frac{3}{32}$	$\frac{5}{32}$	7	$1\frac{7}{16}$	$\frac{13}{16}$	$\frac{5}{16}$	$\frac{1}{2}$
$1\frac{3}{4}$	$\frac{7}{16}$	$\frac{5}{16}$	$\frac{1}{8}$	$\frac{3}{16}$	$7\frac{1}{4}$	$1\frac{1}{2}$	$\frac{13}{16}$	$\frac{5}{16}$	$\frac{1}{2}$
2	$\frac{1}{2}$	$\frac{5}{16}$	$\frac{1}{8}$	$\frac{3}{16}$	$7\frac{1}{2}$	$1\frac{9}{16}$	$\frac{7}{8}$	$\frac{3}{8}$	$\frac{1}{2}$
$2\frac{1}{4}$	$\frac{9}{16}$	$\frac{5}{16}$	$\frac{1}{8}$	$\frac{3}{16}$	$7\frac{3}{4}$	$1\frac{9}{16}$	$\frac{7}{8}$	$\frac{3}{8}$	$\frac{1}{2}$
$2\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{8}$	$\frac{1}{8}$	$\frac{1}{4}$	8	$1\frac{5}{8}$	$\frac{7}{8}$	$\frac{3}{8}$	$\frac{1}{2}$
$2\frac{3}{4}$	$\frac{5}{8}$	$\frac{3}{8}$	$\frac{1}{8}$	$\frac{1}{4}$	$8\frac{1}{4}$	$1\frac{5}{8}$	$\frac{15}{16}$	$\frac{3}{8}$	$\frac{9}{16}$
3	$\frac{11}{16}$	$\frac{7}{16}$	$\frac{3}{16}$	$\frac{1}{4}$	$8\frac{1}{2}$	$1\frac{11}{16}$	$\frac{15}{16}$	$\frac{3}{8}$	$\frac{9}{16}$
$3\frac{1}{4}$	$\frac{3}{4}$	$\frac{7}{16}$	$\frac{3}{16}$	$\frac{1}{4}$	$8\frac{3}{4}$	$1\frac{3}{4}$	$\frac{15}{16}$	$\frac{3}{8}$	$\frac{9}{16}$
$3\frac{1}{2}$	$\frac{13}{16}$	$\frac{7}{16}$	$\frac{3}{16}$	$\frac{1}{4}$	9	$1\frac{3}{4}$	1	$\frac{7}{16}$	$\frac{9}{16}$
$3\frac{3}{4}$	$\frac{13}{16}$	$\frac{1}{2}$	$\frac{3}{16}$	$\frac{5}{16}$	$9\frac{1}{4}$	$1\frac{7}{8}$	1	$\frac{7}{16}$	$\frac{9}{16}$
4	$\frac{7}{8}$	$\frac{1}{2}$	$\frac{3}{16}$	$\frac{5}{16}$	$9\frac{1}{2}$	$1\frac{7}{8}$	$1\frac{1}{16}$	$\frac{7}{16}$	$\frac{5}{8}$
$4\frac{1}{4}$	$\frac{15}{16}$	$\frac{9}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$9\frac{3}{4}$	2	$1\frac{1}{16}$	$\frac{7}{16}$	$\frac{5}{8}$
$4\frac{1}{2}$	1	$\frac{9}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	10	2	$1\frac{1}{16}$	$\frac{7}{16}$	$\frac{5}{8}$
$4\frac{3}{4}$	1	$\frac{9}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$10\frac{1}{2}$	$2\frac{1}{8}$	$1\frac{1}{8}$	$\frac{7}{16}$	$\frac{5}{8}$

HAWSE PIPE PROPORTIONS

(SEE TABLE OF WEIGHTS)

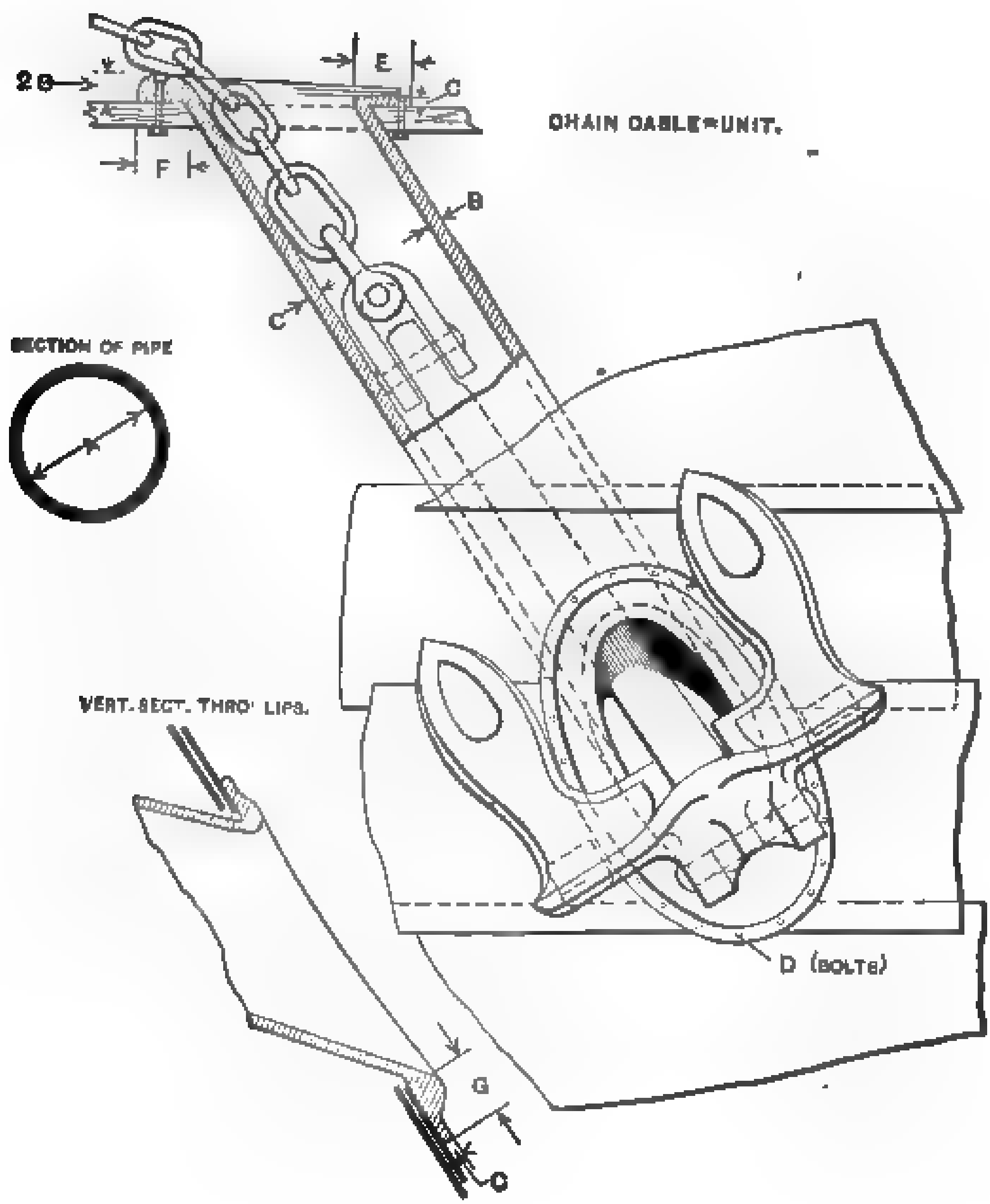


FIG. 266.

$A = 9.0,\ B = 6,\ C = .7,\ D = .5,\ E = 3.5,\ F = 5.0,\ G = 4.7.$

HAWSE PIPE WEIGHT FOR STOCKLESS ANCHORS.

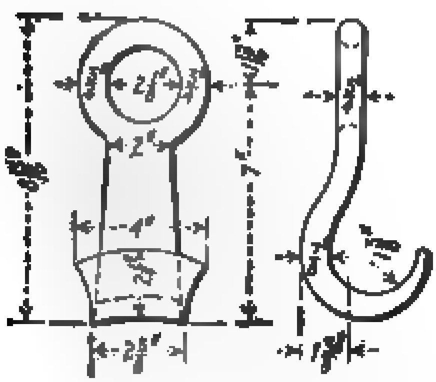
(Including Pipe, Lips, and Deck Ring.)

Cable (Stud Link).	Weight of Hawse Pipe.	Cable (Stud Link).	Weight of Hawse Pipe.
Ins.	Lbs.	Ins.	Lbs.
1	1,000	$2\frac{5}{16}$	4,400
$1\frac{1}{16}$	1,030	$2\frac{3}{8}$	4,700
$1\frac{1}{8}$	1,060	$2\frac{7}{16}$	5,100
$1\frac{3}{16}$	1,100	$2\frac{1}{2}$	5,500
$1\frac{1}{4}$	1,200	$2\frac{9}{16}$	6,000
$1\frac{5}{16}$	1,300	$2\frac{5}{8}$	6,500
$1\frac{3}{8}$	1,400	$2\frac{11}{16}$	7,100
$1\frac{7}{16}$	1,500	$2\frac{3}{4}$	7,700
$1\frac{1}{2}$	1,560	$2\frac{13}{16}$	8,500
$1\frac{9}{16}$	1,700	$2\frac{7}{8}$	9,300
$1\frac{5}{8}$	1,800	$2\frac{15}{16}$	10,200
$1\frac{11}{16}$	2,000	3	11,400
$1\frac{3}{4}$	2,100	$3\frac{1}{16}$	12,750
$1\frac{13}{16}$	2,300	$3\frac{1}{8}$	14,000
$1\frac{7}{8}$	2,500	$3\frac{3}{16}$	15,500
$1\frac{15}{16}$	2,700	$3\frac{1}{4}$	16,500
2	3,000	$3\frac{5}{16}$	18,000
$2\frac{1}{16}$	3,200	$3\frac{3}{8}$	19,500
$2\frac{1}{8}$	3,400	$3\frac{7}{16}$	21,000
$2\frac{3}{16}$	3,750	$3\frac{1}{2}$	22,500
$2\frac{1}{4}$	4,000	. . .	. . . .

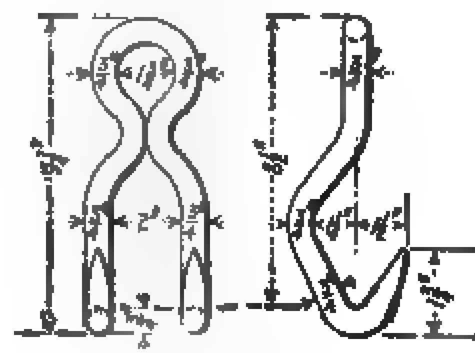
N.B. — Weights given are for one pipe.

HOOKS, VARIOUS.

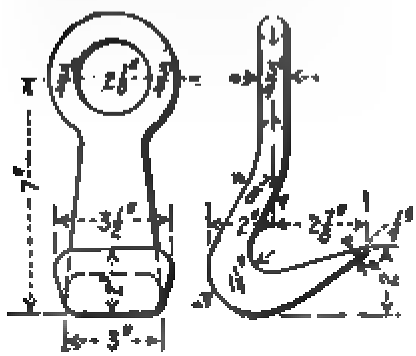
Barrel Hook.



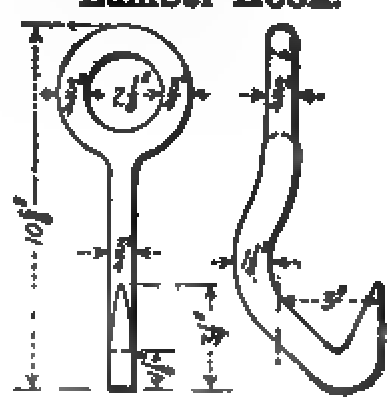
Bale Hook.



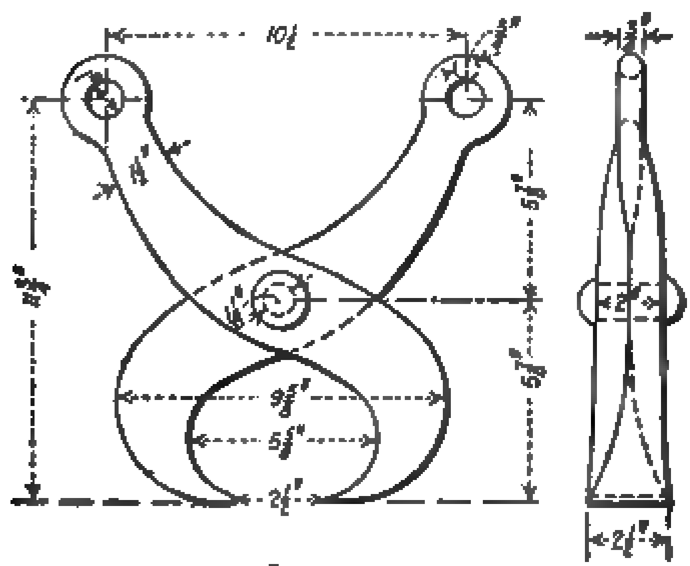
Case Hook.



Lumber Hook.



Rail Hook.



Figs. 267 to 271.

CARGO HOOKS.

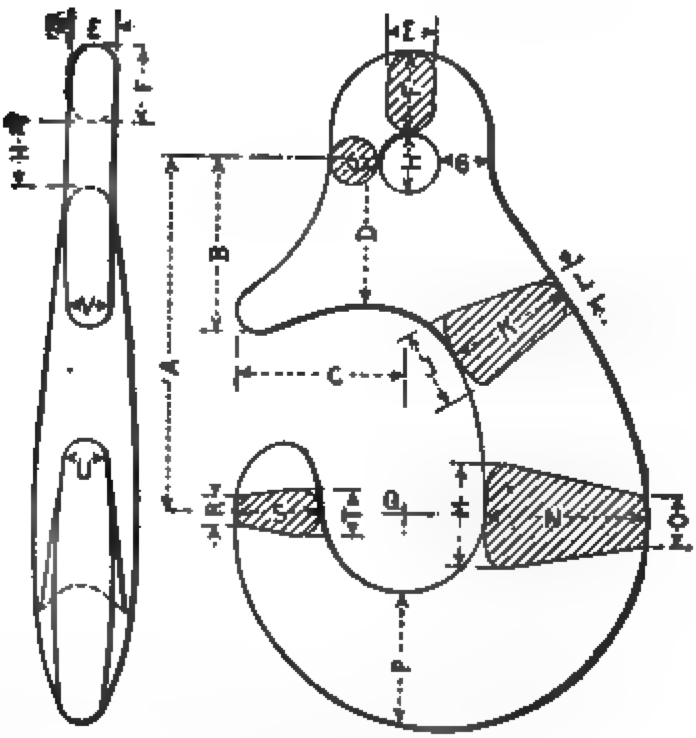


FIG. 272.

LOAD.	A	B	C	D	E	F	G	H	J	K
Tons.	"	"	"	"	"	"	"	"	"	"
1½	4¾	2⅝	1¾	1⅛	¾	1	¾	⅞	1⅜	1⅜
2	5⅓	2¾	2	1⅞	⅞	1⅛	⅞	1	1⅜	1½
3	6	3¼	2¾	2¼	$\frac{15}{16}$	1¼	$\frac{15}{16}$	1⅛	1½	1⅞
4	7⅛	3½	3½	2¼	1	1⅝	1	1¼	1$\frac{11}{16}$	2⅛
5	8¾	4¼	4	2⅝	1⅛	1½	1⅛	1⅜	1¾	2⅜

LOAD.	L	M	N	O	P	Q	R	S	T	U	V
Tons.	"	"	"	"	"	"	"	"	"	"	"
1½	½	1⅝	1⅞	⅝	1⅜	2	$\frac{5}{16}$	1	⅝	½	½
2	⅝	1¾	2¼	¾	1⅝	2⅛	⅜	1⅛	¾	⅝	⅝
3	¾	2	2¾	⅞	2	2¾	½	1¼	⅞	¾	¾
4	1	2$\frac{1}{16}$	3⅜	$\frac{15}{16}$	2⅝	3⅜	⅝	1¾	$\frac{15}{16}$	⅞	$\frac{15}{16}$
5	1⅛	2⅜	4⅛	1	3½	4	¾	1⅞	1	1	1⅛

SWIVEL HOOKS.

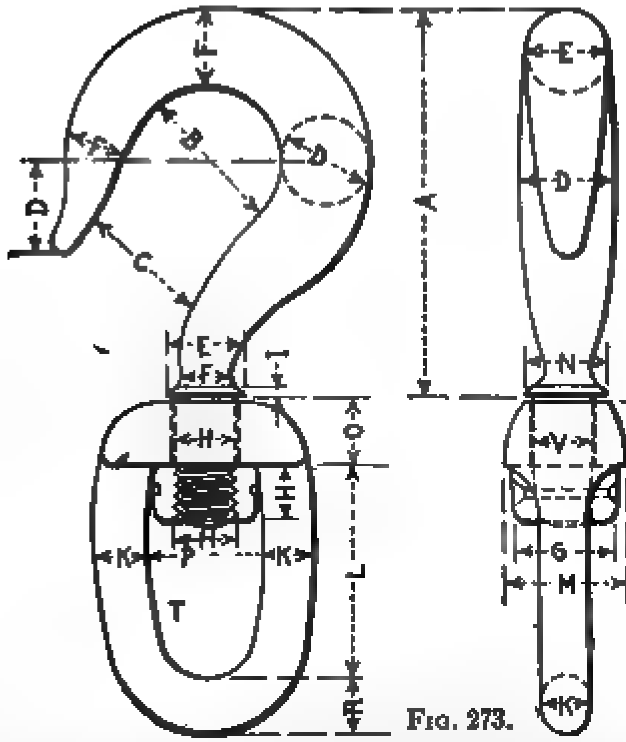


FIG. 273.

Unit D.	Working Load, Lbs.	Dimensions of Hook, in Inches. A	B	C	E	F	G	H	I	Weight in Lbs.
3/4"	700	2 1/4	31/32	27/32	17/32	9/16	23/32	15/32	1/4	0 4
27/32	880	2 17/32	1 1/16	31/32	19/32	5/8	25/32	17/32	1/4	0 55
15/16	1100	3 3/32	1 3/16	1 1/32	5/8	23/32	7/8	9/16	1/4	0 8
31/32	1320	3 15/32	1 9/32	1 5/32	23/32	13/16	29/32	19/32	9/32	1 01
1	1720	3 13/16	1 3/8	1 9/32	25/32	27/32	1 1/32	21/32	9/32	1 45
1 3/32	2160	4 13/32	1 15/32	1 15/32	27/32	15/16	1 3/32	23/32	5/16	2 2
1 1/4	2820	5 1/32	1 23/32	1 21/32	1 1/32	7/8	1 1/4	27/32	11/32	3 3
1 13/32	3530	5 21/32	2 1/8	1 25/32	1 3/32	29/32	1 3/8	31/32	13/32	4 2
1 9/16	4450	6 5/16	2 11/32	2 1/16	1 1/8	15/16	1 1/2	1	7/16	7 0
1 23/32	5500	7 3/32	2 11/16	2 5/16	1 13/32	31/32	1 21/32	1 3/32	15/32	9 3
1 31/32	6840	7 3/4	2 31/32	2 9/16	1 9/16	1	1 27/32	1 7/32	1/2	11 7
2 3/32	8380	8 23/32	3 9/32	2 27/32	1 21/32	1 3/32	2	1 11/32	9/16	13 3

Unit D.	Working Load, Lbs	Dimensions of Swivel, in Inches. K	L	M	N	O	P	R	T	V	Weight in Lbs.
3/4"	700	11/32	1 3/8	7/8	21/32	7/16	25/32	7/16	5/16	17/32	0 4
27/32	880	13/32	1 17/32	31/32	23/32	15/32	7/8	7/16	5/16	9/16	0 55
15/16	1100	15/32	1 11/16	1 1/32	25/32	9/16	31/32	15/32	3/8	19/32	0 8
31/32	1320	7/16	1 13/16	1 5/32	7/8	19/32	1	17/32	13/32	5/8	1 01
1	1720	15/32	2 1/32	1 7/32	31/32	23/32	1 5/32	9/16	7/16	23/32	1 45
1 3/32	2160	17/32	2 5/16	1 3/8	1 1/16	25/32	1 5/16	21/32	15/32	3/4	2 2
1 1/4	2820	9/16	2 9/16	1 15/32	1 3/16	7/8	1 3/8	3/4	17/32	7/8	3 3
1 13/32	3530	5/8	2 27/32	1 5/8	1 9/32	1	1 1/2	7/8	7/16	31/32	4 2
1 9/16	4450	21/32	3 3/32	1 25/32	1 13/32	1 3/32	1 5/8	25/32	19/32	1 1/32	7 0
1 23/32	5500	3/4	3 13/32	2 1/32	1 5/8	1 1/4	1 25/32	7/8	21/32	1 3/32	9 3
1 31/32	6840	25/32	4 1/16	2 11/32	1 13/16	1 3/8	1 31/32	31/32	3/4	1 1/4	11 7
2 3/32	8380	7/8	4 15/32	2 9/16	1 31/32	1 17/32	2 7/32	1	27/32	1 3/8	13 3

TRIP HOOKS.

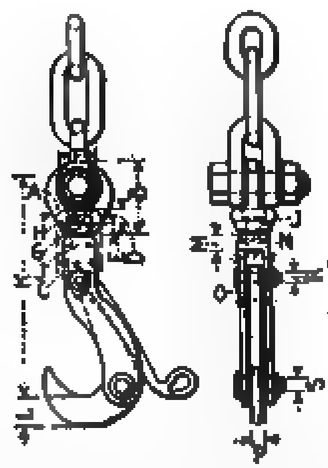


Fig. 274.

A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	R	S
$\frac{1}{2}$	$2\frac{3}{4}$	$1\frac{5}{8}$	$\frac{1}{2}$	$\frac{1}{2}$	$1\frac{1}{2}$	$\frac{5}{8}$	1	$1\frac{1}{4}$	8	1	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{16}$	$\frac{1}{2}$
$\frac{5}{8}$	$3\frac{3}{8}$	2	$\frac{9}{16}$	$\frac{9}{16}$	$1\frac{3}{4}$	$\frac{3}{4}$	$1\frac{1}{8}$	$1\frac{1}{2}$	10	$1\frac{1}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{8}$	$\frac{5}{8}$
$\frac{3}{4}$	4	$2\frac{1}{2}$	$\frac{5}{8}$	$\frac{5}{8}$	$2\frac{3}{8}$	$\frac{7}{8}$	$1\frac{3}{8}$	$1\frac{3}{4}$	12	$1\frac{1}{2}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{1}{2}$	$\frac{3}{4}$
1	$5\frac{1}{2}$	$3\frac{1}{4}$	$\frac{7}{8}$	$\frac{7}{8}$	$2\frac{3}{4}$	$1\frac{1}{4}$	$1\frac{7}{8}$	$2\frac{1}{2}$	16	2	$1\frac{1}{8}$	$1\frac{1}{4}$	1	$1\frac{1}{16}$	$\frac{5}{8}$	1
$1\frac{1}{4}$	$6\frac{3}{4}$	4	$1\frac{1}{8}$	$1\frac{1}{8}$	$3\frac{1}{2}$	$1\frac{1}{2}$	$2\frac{1}{4}$	3	20	$2\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{4}$	$1\frac{5}{16}$	$\frac{3}{4}$	$1\frac{1}{4}$
$1\frac{1}{2}$	8	$4\frac{3}{4}$	$1\frac{3}{8}$	$1\frac{3}{8}$	$4\frac{1}{4}$	$1\frac{3}{4}$	$2\frac{3}{4}$	$3\frac{1}{2}$	24	3	$1\frac{3}{4}$	$1\frac{3}{4}$	$1\frac{1}{2}$	$1\frac{9}{16}$	$\frac{7}{8}$	$1\frac{1}{2}$

DIMENSIONS OF STANDARD PAD-EYES.

Working Load		A	B	C	D	E	F	G	H	J	K	Number of Rivets or Bolts for Fastening: 2	4	6	8	10	Weight = 5.14 A³
Lbs.	T					For 2 Bolts						Diameters.					Lbs.
		"	"	"	"	"	"	"	"	"		"	"	"	"	"	
560	1/4	5/16	1/8	3/16	5/32	1 5/16	1 1/16	1 3/4	1	...	1 1/4 Diameter of Rivet.	5/16	....	...	...	...	.15
1,120	1/2	7/16	3/16	1/4	7/32	2 5/16	1 9/16	2 1/8	1 1/8	...		3/8	....	...	...	...	.30
2,240	1	9/16	1/4	5/16	9/32	2 13/16	2	2 3/4	1 1/4	1 1/4		7/16	5/16	...	...	...	.92
3,360	1 1/2	11/16	1/4	3/8	11/32	3 7/16	2 1/2	3 3/8	1 1/2	1 1/2		1/2	7/16	...	...	...	1.67
4,480	2	13/16	5/16	1/2	13/32	4 1/16	3	4	2 1/4	2 1/4		9/16	1/2	...	...	...	2.77
6,720	3	1	3/8	5/8	7/16	5	3 1/2	4 3/4	2 3/4	2 1/2		5/8	1/2	1/2	...	...	5.14
8,960	4	1 1/8	3/8	11/16	9/16	5 5/8	4	5 5/8	3 1/4	2 3/4		....	....	...	...	...	7.30
11,200	5	1 1/4	7/16	3/4	5/8	6 1/4	4 3/8	6	3 1/2	3 1/4		3/4	5/8	5/8	...	...	10.02
13,440	6	1 3/8	1/2	7/8	11/16	6 3/4	4 3/4	6 5/8	3 3/4	3 3/4		....	....	...	...	...	13.31
15,680	7	1 1/2	9/16	1	3/4	7 1/4	5 1/4	7 1/4	4 1/4	4		1	3/4	3/4	5/8	...	17.32
17,920	8	1 5/8	5/8	1 1/16	13/16	8 1/4	5 11/16	8	4 1/2	4 1/4		....	....	...	...	...	22.05
20,160	9	1 3/4	11/16	1 1/8	7/8	8 5/8	6 1/8	8 1/2	4 3/4	4 1/2		1 1/8	1	7/8	3/4	5/8	27.56
22,400	10	1 7/8	11/16	1 3/16	15/16	9 1/4	6 9/16	9	5	4 3/4		....	....	...	...	...	33.87
26,880	12	2	3/4	1 1/4	1	10	7	9 5/8	5 1/4	5 1/4		1 1/4	1 1/8	1	7/8	3/4	41.12
31,360	14	2 1/4	13/16	...	1 1/16	10 5/8	7 1/2	10	5 3/4	5 1/2		....	1 1/4	...	...	...	49.34
35,840	16	2 1/2	7/8	...	1 1/8	11 1/2	7 7/8	10 1/4	6 1/4	5 3/4		1 3/8	....	1 1/8	1	7/8	58.59
40,320	18	2 5/8	7/8	...	1 3/16	...	...	11 1/2	...	6 1/4		....	1 1/4	...	...	...	68.87
44,800	20	2 3/4	1	...	1 1/4	...	...	12	...	6 3/4		....	....	1 1/4	1 1/8	1	80.28
56,000	25	2 7/8	1	...	1 5/16	...	...	13 1/2	...	7 1/4		....	....	...	...	...	121.87
67,200	30	3	1 1/8	...	1 3/8	...	...	14 1/2	...	7 3/4		....	....	1 3/8	1 1/4	1 1/8	138.78
78,400	35	3 1/4	1 1/8	...	1 1/2	...	...	15 3/4	...	8 1/2		....	....	...	...	...	176.45
89,600	40	3 1/2	1 1/4	...	1 5/8	...	...	17	...	9 1/4		....	....	...	1 3/8	1 1/4	220.35
108,000	45	3 3/4	1 1/4	...	1 3/4	...	...	18	...	9 3/4		....	....	...	...	...	271.03
112,000	50	4	1 3/8	...	2	...	...	19 1/2	...	10 1/2		....	....	...	...	1 3/8	326.96

Stress in Eye = 2 Tons per Square Inch. Stress in Rivets 3.81 Tons per Square Inch.

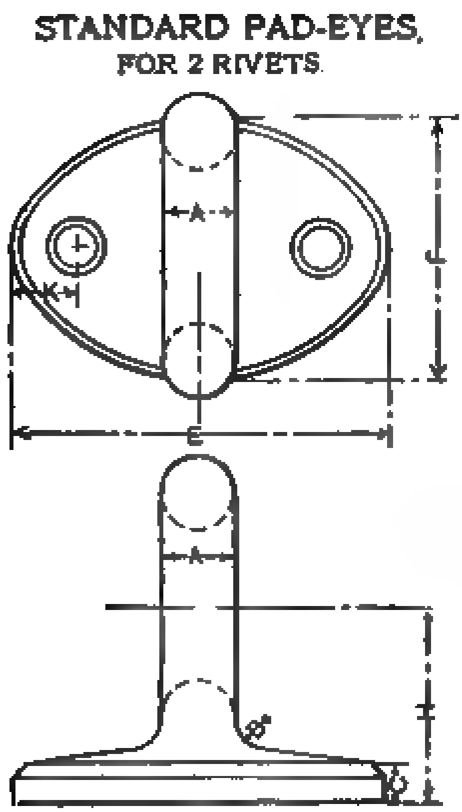


FIG. 275.

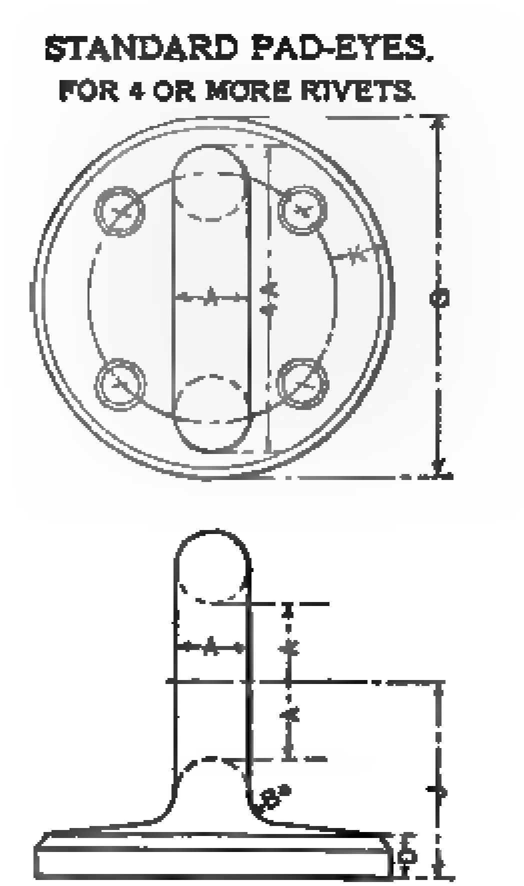


FIG. 276.

REVERSIBLE PAD-EYE.

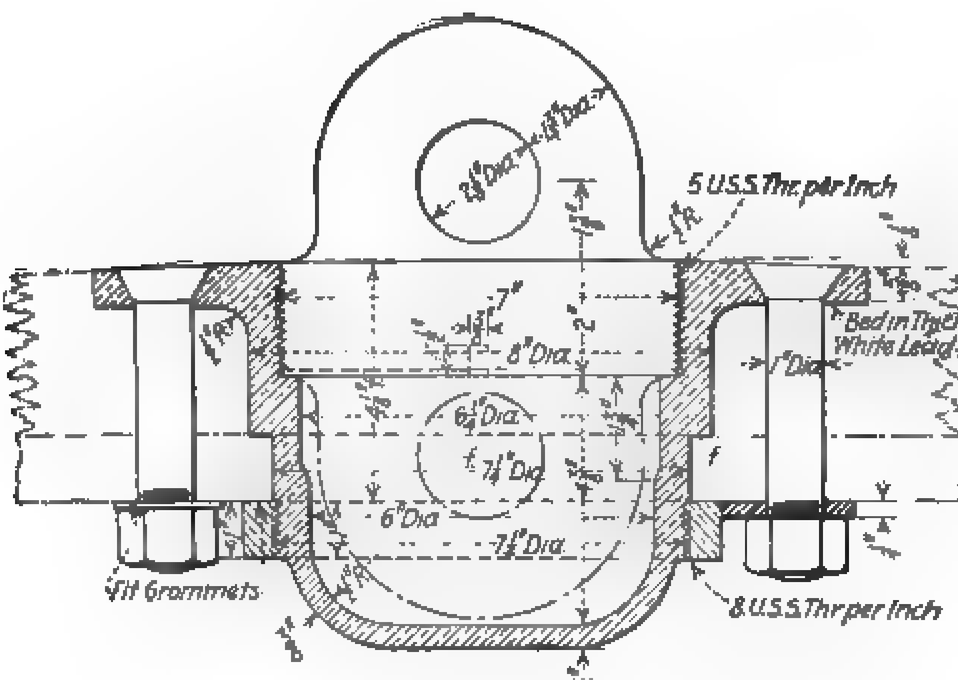


FIG. 277.

LEWIS BOLT.

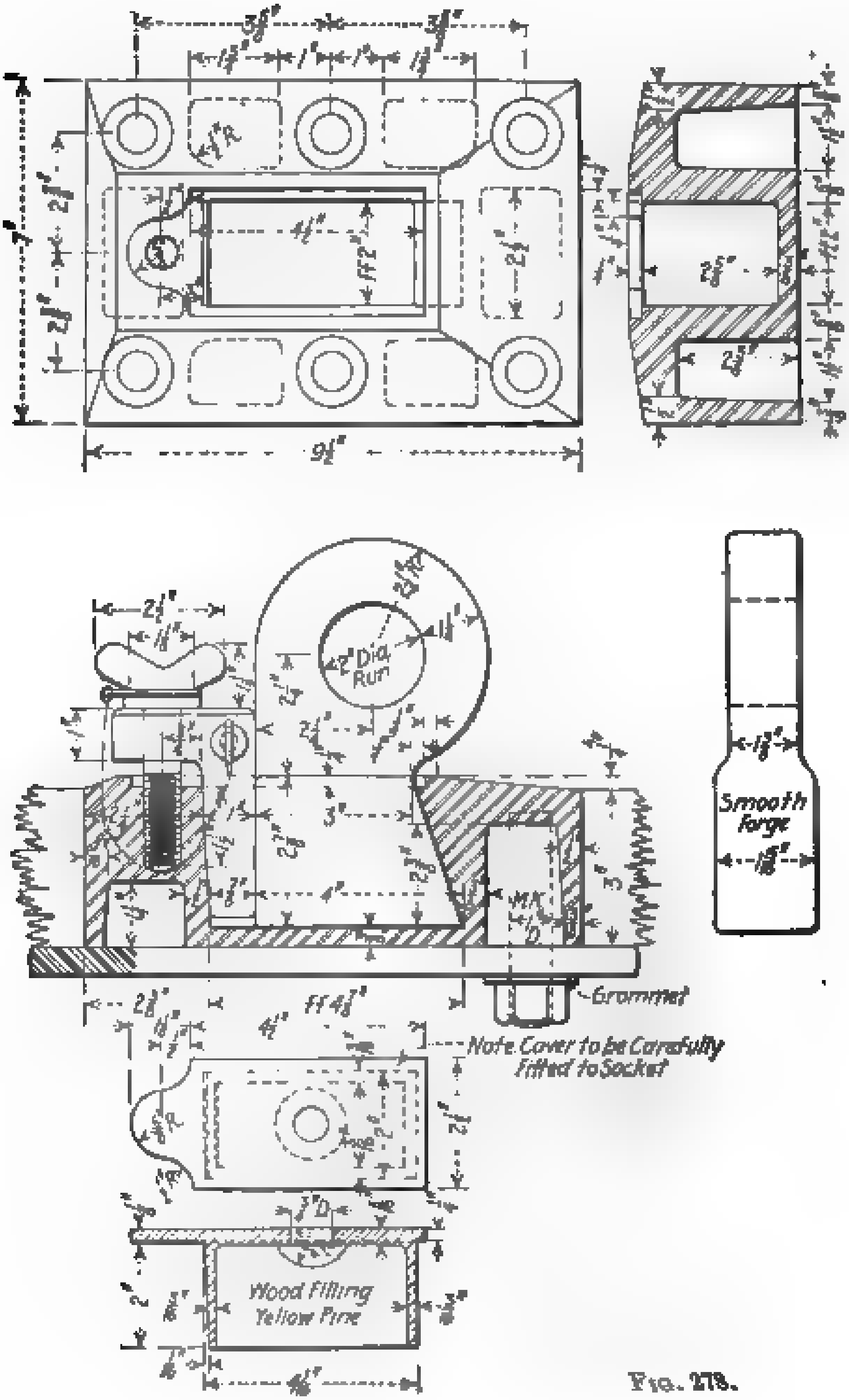


Fig. 278.

ACCOMMODATION LADDERS.

Length of ladder.	10′-0″	12′-0″	15′-0″	18′-0″	21′-0″	24′-0″	27′-9″
Breadth of ladder.........	1′-6″	1′-9″	2′-0″	2′-3″	2′-6″	2′-9″	2′-6″
Sides............	6″×1 1/4″	6 1/2″×1 3/8″	7″×1 1/2″	7 1/2″×1 3/8″	8″×2″	8″×2″	10″×1 1/2″
Steps, thickness..	1 1/8″	1 1/8″	1 1/4″	1 1/4″	1 1/2″	1 1/2″	1/2″
Platform........	2′-6″×2′-3″	2′-6″×2′-3″	3′-0″×2′-6″	3′-0″×2′-9″	3′-3″×3′-0″	3′-6″×3′-3″	4′-9 1/4″×3′-4 1/4″ 2′-11 1/4″×2′-7 1/4″
Platform thickness...........	1 3/8″	1 1/2″	1 1/2″	1 3/4″	2″	2″	2 3/4″
Platform frame..	2″×3/16″	2 1/2″×5/16″	2 1/2″×3/8″	3″×7/16″	3″×1/2″	3″×9/16″	3″×2 1/2″ ×4.5 lb. angle
Stay............	1 1/4″	1 3/8″	1 1/2″	1 5/8″	1 3/4″	1 7/8″	1 3/4″ diam. lower×1 1/2″
Pins.............	5/8″	3/8″	3/4″	7/8″	1″	1″	7/8″ diam.
Hinge thickness..	3/8″-3/16″	1/2″-1/4″	5/8″-1/4″	5/8″-5/16″	3/4″-5/16″	3/4″-5/16″	....
Hinge length....	15″	18″	20″	22″	24″	24″	....
Ladder binding bolts..........	5/8″	3/8″	3/4″	3/4″	7/8″	7/8″	1/2″
Chain...........	4″	1/4″	1/4″	1/4″	5/16″	5/16″	7/16″
Rope equivalent.	2 1/2″	2 1/2″	3″	3″	3 1/2″	3 1/2″	2 3/4″ Man.
Bridle for chain	2″×5/16″ to 1″×5/16″	2 1/2″×5/16″ to 1 1/2″×5/16″	2 1/2″×3/8″ to 1 1/2″×3/8″	3″×7/16″ to 1 1/2″×7/16″	3″×1/2″ to 1 1/2″×1/2″	3″×9/16″ to 1 1/2″×9/16″	7/16″
Davit diam.....	1 7/8″	2″	2 1/4″	2 1/2″	2 3/4″	3″	3 1/2″ diam.
Sheave.........	4″×1″	4″×1″	4″×1″	4″×1″	5″×1 1/4″	5″×1 1/4″	4 1/2″×1″
Pin for sheave...	1/2″	1/2″	1/2″	1/2″	5/8″	5/8″	1/2″

LASHING TRIANGLES.

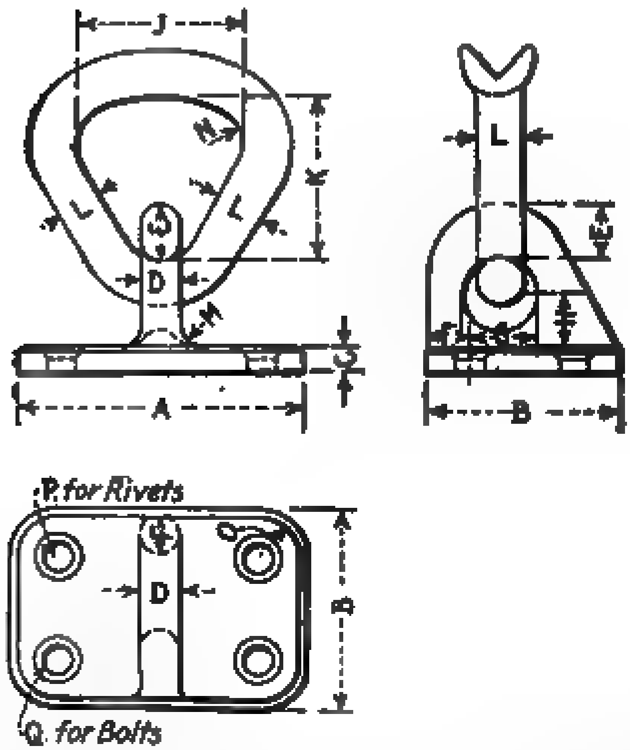


Fig. 279.

For Wire.	A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q
"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
2	$5\frac{1}{4}$	$4\frac{1}{4}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{7}{8}$	$\frac{3}{4}$	$1\frac{1}{4}$	1	$2\frac{1}{4}$	$2\frac{1}{4}$	$\frac{7}{8}$	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{5}{8}$	$\frac{1}{2}$	$\frac{5}{8}$
$2\frac{1}{2}$	$5\frac{1}{2}$	$4\frac{1}{2}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$\frac{3}{4}$	$1\frac{3}{8}$	$1\frac{1}{8}$	3	3	1	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{5}{8}$	$\frac{3}{4}$
3	$6\frac{3}{4}$	5	$\frac{5}{8}$	$\frac{7}{8}$	$1\frac{1}{4}$	$\frac{7}{8}$	$1\frac{1}{2}$	$1\frac{1}{4}$	$3\frac{3}{4}$	$3\frac{3}{4}$	$1\frac{1}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{7}{8}$	$\frac{3}{4}$	
$3\frac{1}{2}$	8	$5\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{2}$	1	$1\frac{15}{16}$	$1\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{2}$	$1\frac{3}{8}$	$\frac{9}{16}$	$\frac{7}{8}$	$1\frac{1}{8}$	$\frac{7}{8}$	..
$4\frac{1}{2}$	9	6	$\frac{7}{8}$	$1\frac{1}{4}$	$1\frac{3}{4}$	$1\frac{1}{4}$	$2\frac{3}{8}$	$1\frac{5}{8}$	$5\frac{1}{4}$	$5\frac{1}{4}$	$1\frac{1}{2}$	$\frac{5}{8}$	$1\frac{1}{8}$	$1\frac{3}{8}$	1	...

MOORING PIPES.

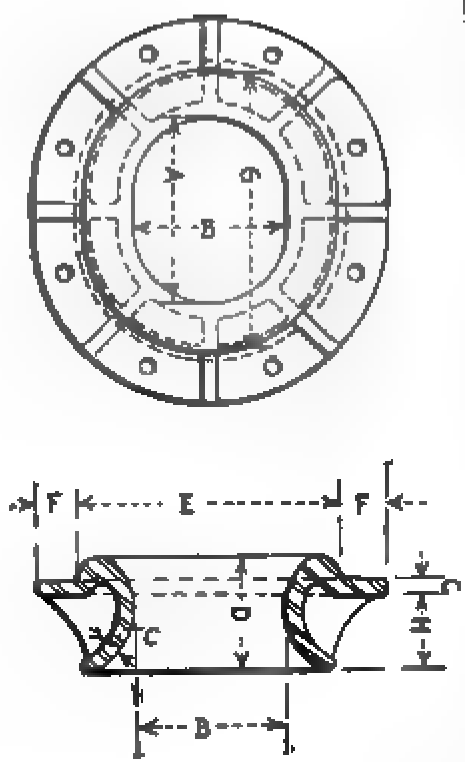


Fig. 280.

Length of Ship	Circum Towline. Man.la.	Circum Towline. Steel	No. of Ribs.	Rivets No.	Rivets Dia.	a	b	c	d	e	f	g	h	Approx. Weight.
Ft	Ins	Ins.			Ins.									Lbs.
40	4	2	4	4	7/16	4	3½	⅜	2½	5½	1	5¾	1½	7
60	6	2¼	4	4	7/16	6	4½	7/16	3¼	8¾	1¼	8¾	2¼	21
100	7	2½	6	6	½	7	5½	½	4¼	9¾	1 7/16	10	2½	33
140	8	3	6	6	⅝	8	6¼	9/16	4¾	11¼	1¾	11¼	3¼	52
180	9	3¼	8	8	¾	9	7½	⅝	5¾	12½	2	13	3¾	73
220	10	3½	8	8	¾	10	8	11/16	6	14	2¼	14½	4	100
260	11	3¾	8	8	¾	11	8¾	¾	6½	15½	2½	16	4¾	131
300	12	4	8	8	⅞	12	9¼	¾	7¼	16¾	2¾	17¾	4¾	169
350	13	4½	8	8	⅞	13	10¼	⅞	7¾	18¼	3	18¾	5¼	220
400	14	4¾	10	10	1	14	11½	1	8¾	19¾	3¼	20½	5¾	274
450	15	5	10	10	1	15	12	1⅛	9	21	3¼	21¾	6	335
500	16	6	10	10	1	16	12¾	1⅛	9½	22¾	3½	23¼	6¼	403
550	17	7	10	10	1	17	13½	1¼	10¼	23¾	3¾	24½	6¾	482
600	18	7½	10	10	1⅛	18	14¼	1¼	10¾	25¼	4	26	7¼	583
630	19	7¾	12	12	1⅛	19	15¼	1¼	11¾	26½	4¼	27½	7½	683
660	20	8	12	12	1⅛	20	16	1⅜	12	28	4½	29	8	793
700	21	8¼	12	12	1¼	21	16¾	1⅜	12¾	29¾	4¾	30½	8¾	914
730	22	8½	12	12	1¼	22	17½	1⅜	13¼	30¾	5	31¾	8¾	1047
760	23	9	12	12	1¼	23	18¼	1⅜	13¾	32¼	5¼	33¼	9¼	1214
800	24	9	12	12	1¼	24	19¼	1½	14½	33½	5½	34¾	9¾	1372

These mooring pipes may be made circular to mean diameter and rivet holes spaced from template which permits of the pipes being moved around one hole at a time as bearing surface gets worn.

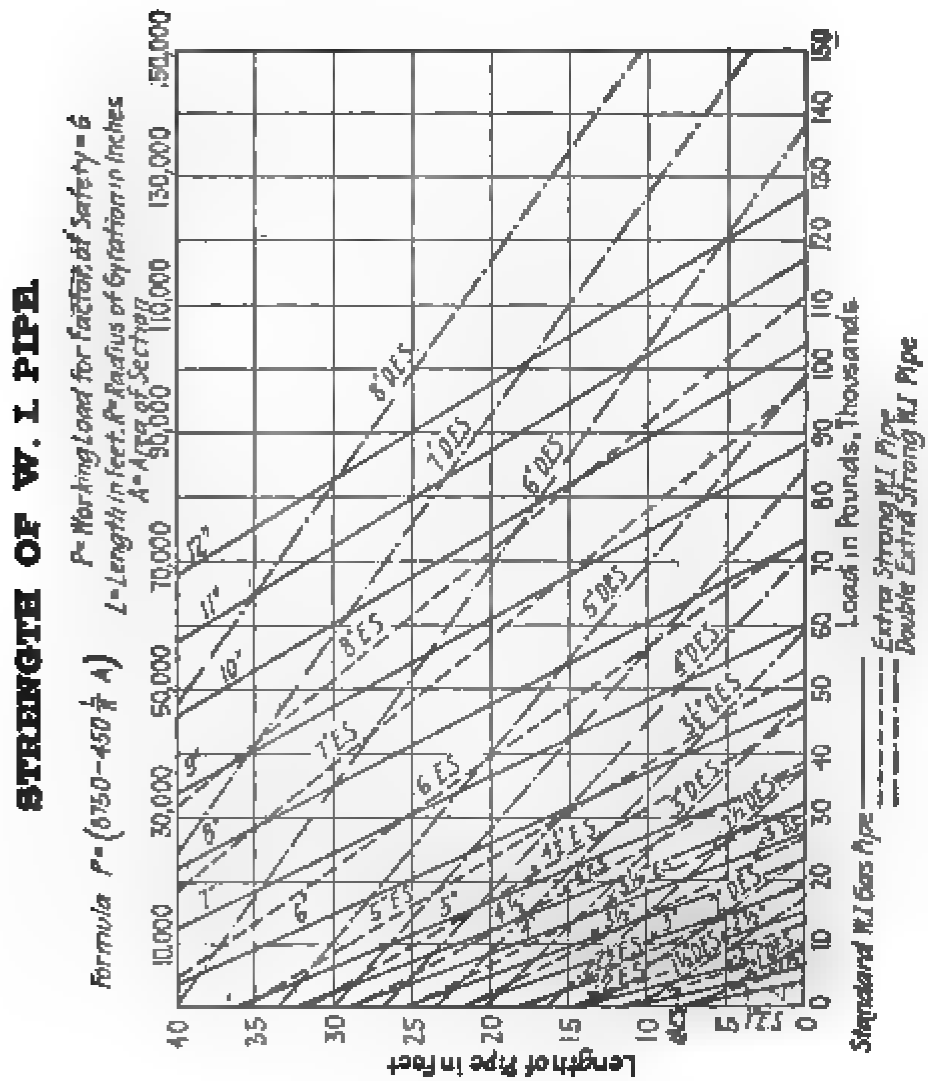

STRENGTH OF W. I. PIPE
Formula $P=(6750-450\frac{L}{R}A)$
P= Working Load for Factor of Safety = 6
L= Length in feet. R= Radius of Gyration in Inches
A= Area of Section
Load in Pounds, Thousands
Length of Pipe in feet
Standard W.I. Gas Pipe
Extra Strong W.I. Pipe
Double Extra Strong W.I. Pipe
8" D.E.S.
7" D.E.S.
6" D.E.S.
5" D.E.S.
4" D.E.S.
8" E.S.
7" E.S.
6" E.S.
5" E.S.
12"
11"
10"
9"
8"
7"
6"
5"
4½"
10,000
30,000
50,000
70,000
90,000
110,000
130,000
150,000

FIG. 28L

PLUG COCK KEYS.

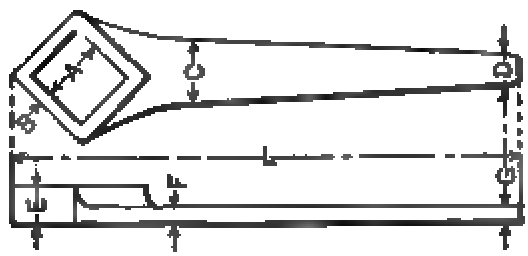
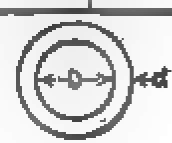


Fig. 282.

A.	B.	C.	D.	E.	F.	G.	L.
"	"	"	"	"	"	"	"
$\frac{3}{4}$	$\frac{1}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{11}{16}$	$\frac{5}{16}$	$\frac{5}{16}$	5
$\frac{7}{8}$	$\frac{1}{4}$	$\frac{7}{8}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{5}{16}$	$\frac{5}{16}$	6
1	$\frac{1}{4}$	1	$\frac{7}{8}$	$\frac{3}{4}$	$\frac{3}{8}$	$\frac{3}{8}$	7
$1\frac{1}{8}$	$\frac{1}{4}$	$1\frac{1}{8}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{3}{8}$	$\frac{3}{8}$	8
$1\frac{1}{4}$	$\frac{5}{16}$	$1\frac{1}{4}$	1	1	$\frac{7}{16}$	$\frac{3}{8}$	$8\frac{1}{2}$
$1\frac{3}{8}$	$\frac{5}{16}$	$1\frac{1}{4}$	1	1	$\frac{7}{16}$	$\frac{3}{8}$	$9\frac{1}{2}$
$1\frac{1}{2}$	$\frac{6}{16}$	$1\frac{3}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$\frac{1}{2}$	$\frac{7}{16}$	$10\frac{1}{2}$
$1\frac{5}{8}$	$\frac{6}{16}$	$1\frac{3}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$\frac{1}{2}$	$\frac{7}{16}$	11
$1\frac{3}{4}$	$\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$\frac{1}{2}$	$\frac{7}{16}$	12
$1\frac{7}{8}$	$\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{1}{8}$	$1\frac{1}{4}$	$\frac{1}{2}$	$\frac{7}{16}$	13
2	$\frac{3}{8}$	$1\frac{3}{4}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$\frac{9}{16}$	$\frac{7}{16}$	14
$2\frac{1}{8}$	$\frac{3}{8}$	$1\frac{3}{4}$	$1\frac{1}{4}$	$1\frac{1}{2}$	$\frac{9}{16}$	$\frac{7}{16}$	15
$2\frac{1}{4}$	$\frac{7}{16}$	2	$1\frac{1}{4}$	$1\frac{1}{2}$	$\frac{5}{8}$	$\frac{1}{2}$	$15\frac{1}{2}$
$2\frac{3}{8}$	$\frac{7}{16}$	2	$1\frac{1}{4}$	$1\frac{1}{2}$	$\frac{5}{8}$	$\frac{1}{2}$	$16\frac{1}{2}$
$2\frac{1}{2}$	$\frac{7}{16}$	$2\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{5}{8}$	$\frac{11}{16}$	$\frac{1}{2}$	$17\frac{1}{2}$
$2\frac{5}{8}$	$\frac{7}{16}$	$2\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{3}{4}$	$\frac{11}{16}$	$\frac{1}{2}$	18
$2\frac{3}{4}$	$\frac{7}{16}$	$2\frac{3}{8}$	$1\frac{3}{8}$	$1\frac{3}{4}$	$\frac{3}{4}$	$\frac{1}{2}$	19
$2\frac{7}{8}$	$\frac{1}{2}$	$2\frac{3}{8}$	$1\frac{3}{8}$	$1\frac{7}{8}$	$\frac{3}{4}$	$\frac{1}{2}$	20
3	$\frac{1}{2}$	$2\frac{1}{2}$	$1\frac{3}{8}$	2	$\frac{3}{4}$	$\frac{9}{16}$	21

STRENGTH OF RINGS.

Diam. of Ring (Outside), Ins.	Diameter of Wire.												
	½ In	¾ In	1 In	1¼ In.	1½ In	1¾ Ins.	2 Ins.	2¼ Ins.	2½ Ins.	2¾ Ins.	3 Ins.	3½ Ins.	4 Ins.
1	4800	12,100											
1¼	4100	11,100	22,000				Load to produce deformation. Safe load take one-half.						
1½	3500	10,100	20,500	34,500									
1¾	3200	9,400	19,000	32,200	49,000								
2	2800	8,700	17,800	30,200	46,300	67,500							
2¼	2600	8,100	16,600	28,300	43,700	64,500	91,200						
2½	2400	7,700	15,500	26,500	41,500	62,700	87,400	117,200					
2¾	2200	7,100	14,500	24,800	39,300	58,900	83,900	112,900	145,600				
3	2100	6,600	13,600	23,500	37,300	56,300	80,600	108,900	140,000	174,500			
3¼	1900	6,200	12,900	22,200	35,400	54,000	77,600	105,400	135,800	169,300	208,000		
3½	1800	5,900	12,200	21,300	34,000	51,800	74,700	102,000	132,000	164,200	202,000		
3¾	1700	5,500	11,600	20,400	32,700	50,100	72,000	98,600	128,100	159,300	196,200	282,100	
4	1600	5,100	11,200	19,500	31,500	48,100	69,400	95,400	124,500	154,700	190,100	278,000	
4½		4,800	10,100	17,900	29,100	44,800	65,000	92,000	127,800	146,500	181,000	264,300	365,100
5		4,300	9,300	16,600	27,100	41,800	61,000	85,000	111,500	139,000	171,800	251,000	348,200
5½			8,700	15,500	25,200	39,300	57,500	80,000	105,400	132,300	163,600	239,500	333,200
6			8,100	14,500	23,800	37,200	54,500	75,300	99,700	125,600	156,300	229,400	320,000
6½				13,700	22,700	35,500	51,700	71,400	95,400	119,700	149,500	220,100	308,000
7				13,100	21,700	33,900	49,200	67,800	89,600	114,100	143,300	211,700	296,800
7½					20,900	32,400	46,000	64,600	85,100	109,200	137,400	204,800	286,500
8					20,200	31,200	45,000	61,700	81,500	105,200	132,300	197,900	277,400
8½						29,900	43,000	58,900	78,200	101,100	127,200	191,000	269,200
9						28,700	41,300	56,700	75,400	97,700	122,700	184,700	261,900
9½							39,600	54,600	72,800	94,200	118,500	178,000	255,000
10							38,300	52,800	70,200	91,200	114,600	172,400	248,800



Strength of rings,

$$f = \frac{8W}{d^3}(0.1175\,D + 0.197\,d), \text{ where } f = 60,000 \text{ lbs.}$$

WROUGHT IRON RINGS.

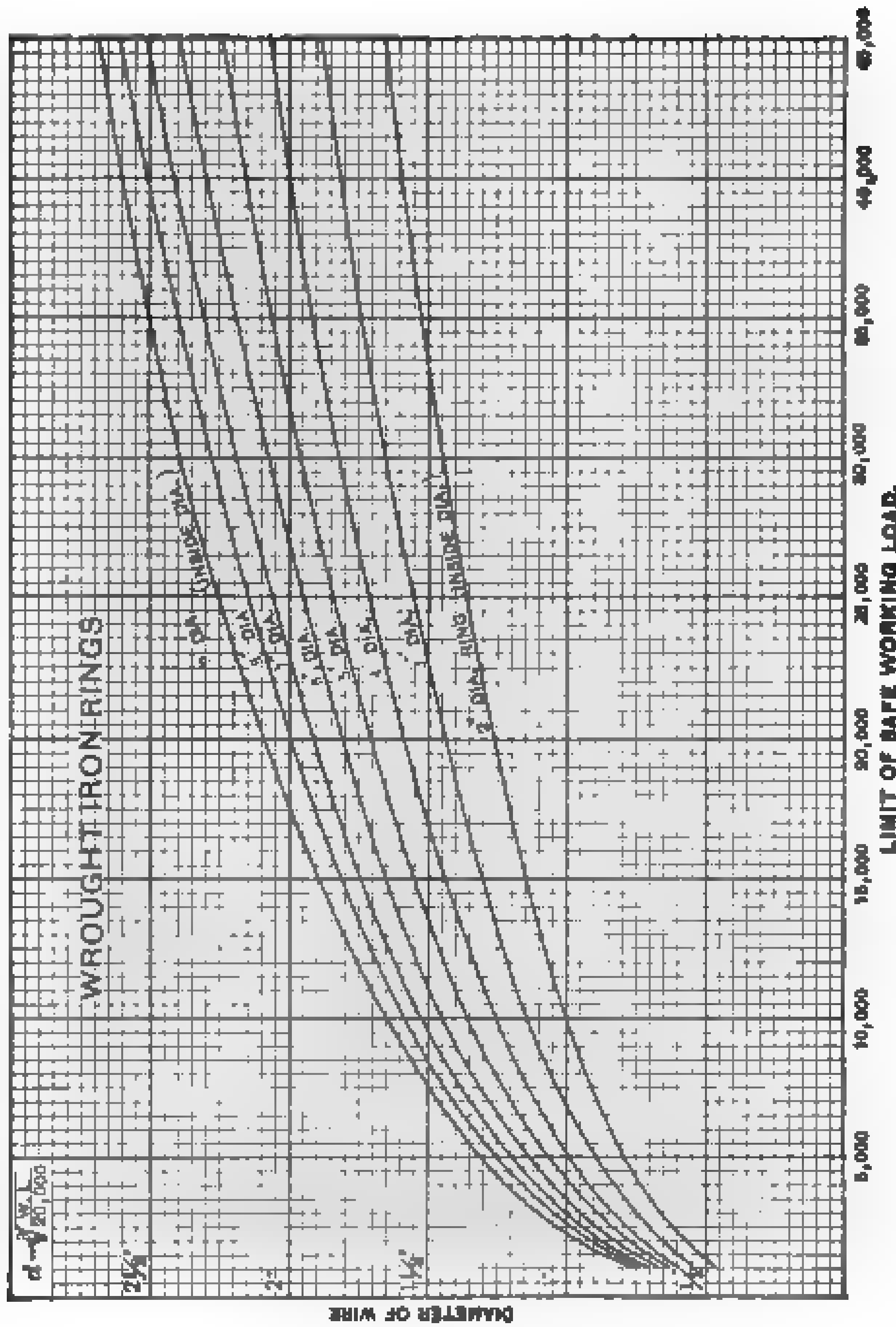


TABLE II.—Proportions of Rings for Standard Short-link Chains.

5/16" Chain.		3/8" Chain.		7/16" Chain.		1/2" Chain.	
P.L. 1¼ Tons.		P.L. 1¾ Tons.		P.L. 2½ Tons.		P.L. 3 Tons.	
M.S.	M.I.D.	M.S.	M.I.D.	M.S.	M.I.D.	M.S.	M.I.D.
"	"	"	"	"	"	"	"
7/16	1	9/16	1½	5/8	1¾	11/16	1 5/16
1/2	1 9/16	5/8	2 3/16	11/16	2	3/4	1⅞
9/16	2 5/16	11/16	3	3/4	2¾	13/16	2½
5/8	3 7/16	3/4	4 1/16	13/16	3⅝	7/8	3 5/16
11/16	4 11/16	13/16	5 3/16	7/8	4 11/16	15/16	4 3/16
3/4	6¼	7/8	6⅞	15/16	5 15/16	1	5¼
...	...	...	...	1	7 5/16	1 1/16	6 7/16
...	...	...	...	...	...	1⅛	7¾

9/16" Chain.		5/8" Chain.		11/16" Chain.		3/4" Chain.	
P.L. 3¾ Tons.		P.L. 4½ Tons.		P.L. 5¼ Tons.		P.L. 6¾ Tons.	
M.S.	M.I.D.	M.S.	M.I.D.	M.S.	M.I.D.	M.S.	M.I.D.
"	"	"	"	"	"	"	"
13/16	1⅞	7/8	1 13/16	15/16	1¾	1 1/16	2¼
7/8	2 7/16	15/16	2⅜	1	2 5/16	1⅛	2 13/16
15/16	3 3/16	1	3 3/16	1 1/16	2 15/16	1 3/16	3 7/16
1	4	1 1/16	3 15/16	1⅛	3⅝	1¼	4⅛
1 1/16	4 15/16	1⅛	4⅝	1 3/16	4 5/16	1 5/16	4 15/16
1⅛	5 15/16	1 3/16	5 9/16	1¼	5¼	1⅜	5 13/16
1 3/16	7⅛	1¼	6⅝	1 5/16	6 9/16	1 7/16	6¾
1¼	8 7/16	1 5/16	7 13/16	1⅜	7¼	1½	7⅞
...	...	1⅜	9⅛	1 7/16	8⅜	1 9/16	9
...	...	...		1½	9¾	1⅝	10¼

TABLE II.— *(Continued.)*

13/16" Chain.		7/8" Chain.		15/16" Chain.		1" Chain.	
P.L. 7 3/16 Tons.		P.L. 9 1/8 Tons.		P.L. 10 1/2 Tons.		P.L. 12 Tons.	
M.S.	M.I.D.	M.S.	M.I.D.	M.S.	M.I.D.	M.S.	M.I.D.
"	"	"	"	"	"	"	"
1 1/8	2 1/4	1 1/4	2 3/4	1 5/16	2 11/16	1 3/8	2 5/8
1 3/16	2 3/4	1 5/16	3 5/16	1 3/8	3 1/4	1 7/16	3 3/16
1 1/4	3 3/8	1 3/8	3 15/16	1 7/16	3 7/8	1 1/2	3 3/4
1 5/16	4	1 7/16	4 11/16	1 1/2	4 1/2	1 9/16	4 5/16
1 3/8	4 3/4	1 1/2	5 7/16	1 9/16	5 1/4	1 5/8	5
1 7/16	5 9/16	1 9/16	6 1/4	1 5/8	6	1 11/16	5 3/4
1 1/2	6 7/16	1 5/8	7 3/16	1 11/16	6 7/8	1 3/4	6 1/2
1 9/16	7 3/8	1 11/16	8 3/16	1 3/4	7 3/4	1 13/16	7 7/16
1 5/8	8 3/8	1 3/4	9 1/4	1 13/16	8 3/4	1 7/8	8 3/8
1 11/16	9 11/16	1 13/16	10 3/8	1 7/8	9 13/16	1 15/16	9 3/8
....	....	....	......	..	....	2	10 7/16

1 1/16" Chain.		1 1/8" Chain.		1 3/16" Chain.		1 1/4" Chain.	
P.L. 13 3/4 Tons.		P.L. 15 1/8 Tons.		P.L. 16 9/16 Tons.		P.L. 18 3/4 Tons.	
M.S.	M.I.D.	M.S.	M.I.D.	M.S.	M.I.D.	M.S.	M.I.D.
"	"	"	"	"	"	"	"
1 1/2	3 3/16	1 9/16	3 3/16	1 5/8	3 1/16	1 3/4	3 9/16
1 9/16	3 11/16	1 5/8	3 11/16	1 11/16	3 9/16	1 13/16	4 1/8
1 5/8	4 5/16	1 11/16	4 1/4	1 3/4	4 1/8	1 7/8	4 11/16
1 11/16	4 13/16	1 3/4	4 7/8	1 13/16	4 11/16	1 15/16	5 5/16
1 3/4	5 5/8	1 13/16	5 9/16	1 7/8	5 3/8	2	6
1 13/16	6 7/16	1 7/8	6 5/16	1 15/16	6 1/16	2 1/16	6 1/16
1 7/8	7 5/16	1 15/16	7 1/16	2	6 13/16	2 1/8	7 7/16
1 15/16	8 1/8	2	7 15/16	2 1/16	7 9/16	2 3/16	8
2	9	2 1/16	8 13/16	2 1/8	8 3/8	2 1/4	9 1/8
2 1/16	10	2 1/8	9 3/4	2 3/16	9 5/16	2 5/16	10
2 1/8	11 1/8	2 3/16	10 13/16	2 1/4	10 1/4	2 3/8	11
....	...	2 1/4	11 7/8	2 5/16	11 1/4	2 7/16	12
....	......	.		2 3/8	12 3/8	2 1/2	13 1/16

TABLE II. — *(Continued.)*

1 5/16" Chain.		1 3/8" Chain.		1 7/16" Chain.		1 1/2" Chain.	
P.L. 20 5/8 Tons.		P.L. 22 3/4 Tons.		P.L. 24 3/4 Tons.		P.L. 27 Tons.	
M.S.	M.I.D.	M.S.	M.I.D.	M.S.	M.I.D.	M.S.	M.I.D.
"	"	"	"	"	"	"	"
1 7/8	4 1/16	1 15/16	4 1/16	2	4 1/16	2	4 1/2
1 15/16	4 5/8	2	4 5/8	2 1/16	4 9/16	2 3/16	4 9/16
2	5 1/4	2 1/16	5 3/16	2 1/8	5 1/8	2 1/4	....
2 1/16	5 7/8	2 1/8	5 3/4	2 3/16	5 3/4	2 5/16	6 3/16
2 1/8	6 9/16	2 3/16	6 3/8	2 1/4	6 3/8	2 3/8	6 7/8
2 3/16	7 5/16	2 1/4	7 1/8	2 5/16	6 15/16	2 7/16	7 1/2
2 1/4	8 1/16	2 5/16	7 13/16	2 3/8	7 3/4	2 1/2	8 1/4
2 5/16	8 15/16	2 3/8	8 11/16	2 7/16	8 7/16	2 9/16	9 1/16
2 3/8	9 3/4	2 7/16	9 1/2	2 1/2	9 3/16	2 5/8	9 7/8
2 7/16	10 11/16	2 1/2	10 5/16	2 9/16	10 1/4	2 11/16	10 11/16
2 1/2	11 5/8	2 9/16	11 1/4	2 5/8	11	2 3/4	11 3/4
2 9/16	12 11/16	2 5/8	12 1/4	2 11/16	11 13/16	2 13/16	12 9/16
2 5/8	13 3/4	2 11/16	13 5/16	2 3/4	12 11/16	2 7/8	13 1/2
....	....	2 3/4	14 3/8	2 13/16	13 13/16	2 15/16	14 9/16
....	....	....	......	2 7/8	15 1/16	3	15 5/8

M.S. = Minimum size of iron in ring.

M.I.D. = Maximum internal diameter of ring.

$$\text{P.L.} = \text{Proof load} = 18.7\,\frac{d^2}{D},$$

where d = dia. of iron in ring,

and D = mean dia. of ring.

Safe load = One half the proof load.

TABLE III.—Proportions of Rings for Double-leg Sling-Chains.

5/16" Chain.		3/8" Chain.		7/16" Chain.		1/2" Chain.	
P.L. 2¼ Tons.		P.L. 3¼ Tons.		P.L. 4½ Tons.		P.L. 6 Tons	
M.S.	M.I.D.	M.S.	M.I.D.	M.S.	M.I.D.	M.S.	M.I.D.
"	"	"	"	"	"	"	"
5/8	1 3/8	3/4	1 11/16	7/8	1 15/16	1	2 1/8
11/16	2	13/16	2 1/4	15/16	2 1/2	1 1/16	2 11/16
3/4	2 3/4	7/8	3	1	3 3/16	1 1/8	3 5/16
13/16	3 5/8	15/16	3 13/16	1 1/16	3 15/16	1 3/16	4 1/16
7/8	4 11/16	1	4 3/4	1 1/8	4 13/16	1 1/4	4 7/8
15/16	5 13/16	1 1/16	5 13/16	1 3/16	5 3/4	1 5/16	5 3/4
1	7 15/16	1 1/8	7 1/16	1 1/4	6 7/8	1 3/8	6 3/4
1 1/16	8 15/16	1 3/16	8 7/16	1 5/16	8 1/16	1 7/16	7 3/16
1 1/8	10 3/4	1 1/4	10	1 3/8	9 7/16	1 1/2	9
	.		. . .	1 7/16	10 7/8	1 9/16	10 3/8

9/16" Chain.		5/8" Chain.		11/16" Chain.		3/4" Chain.	
P.L. 7½ Tons		P.L. 9¼ Tons.		P.L. 11¼ Tons.		P.L. 13½ Tons.	
M.S.	M.I.D.	M.S.	M.I.D.	M.S.	M.I.D.	M.S.	M.I.D.
"	"	"	"	"	"	"	"
1 1/8	2 7/16	1 1/4	2 11/16	1 3/8	2 15/16	1 1/2	3 3/16
1 3/16	3	1 5/16	3 1/4	1 7/16	3 1/2	1 9/16	3 11/16
1 1/4	3 5/8	1 3/8	3 7/8	1 1/2	4 1/8	1 5/8	4 5/16
1 5/16	4 5/16	1 7/16	4 9/16	1 9/16	4 11/16	1 11/16	4 15/16
1 3/8	5 1/8	1 1/2	5 5/16	1 5/8	5 1/2	1 3/4	5 5/8
1 7/16	5 15/16	1 9/16	6 3/16	1 11/16	6 1/4	1 13/16	6 7/16
1 1/2	6 13/16	1 5/8	7 1/16	1 3/4	7 1/8	1 7/8	7 13/16
1 9/16	7 13/16	1 11/16	8	1 13/16	8 1/16	1 15/16	8 1/2
1 5/8	9 1/16	1 3/4	9 1/16	1 7/8	9 1/16	2	9
1 11/16	10 5/16	1 13/16	10 3/16	1 15/16	10 1/8	2 1/16	10
1 3/4	11 9/16	1 7/8	11 7/16	2	11 1/4	2 1/8	11 1/8
. . .		.		2 1/16	12 1/2	2 3/16	12 1/4

TABLE III. — (*Continued.*)

13/16" Chain.		7/8" Chain.		15/16" Chain.		1" Chain.	
P.L. 15 3/4 Tons.		P.L. 18 1/4 Tons.		P.L. 21 Tons.		P.L. 24 Tons.	
M.S.	M.I.D.	M.S.	M.I.D.	M.S.	M.I.D.	M.S.	M.I.D.
"	"	"	"	"	"	"	"
1 5/8	3 7/16	1 3/4	3 3/4	1 7/8	4	2	4 1/4
1 11/16	4	1 13/16	4 1/4	1 15/16	4 1/2	2 1/16	4 3/4
1 3/4	4 9/16	1 7/8	4 7/8	2	5 1/8	2 1/8	5 3/8
1 13/16	5 3/16	1 15/16	5 1/2	2 1/16	5 3/4	2 3/16	6
1 7/8	5 7/8	2	6 1/8	2 1/8	6 7/16	2 1/4	6 5/8
1 15/16	6 5/8	2 1/16	6 13/16	2 3/16	7 1/8	2 5/16	7 5/16
2	7 7/16	2 1/8	7 11/16	2 1/4	7 7/8	2 3/8	8 1/16
2 1/16	8 5/16	2 3/16	8 1/2	2 5/16	8 11/16	2 7/16	8 7/8
2 1/8	9 5/16	2 1/4	9 3/8	2 3/8	9 9/16	2 1/2	9 11/16
2 3/16	10 3/16	2 5/16	10 5/16	2 7/16	10 7/16	2 9/16	10 9/16
2 1/4	11 3/16	2 3/8	11 5/16	2 1/2	11 7/16	2 5/8	11 5/8
2 5/16	12 3/16	2 7/16	12 5/16	2 9/16	12 7/16	2 11/16	12 7/16
2 3/8	13 7/16	2 1/2	13 1/2	2 5/8	13 1/2	2 3/4	13 5/8
....	...		...	2 11/16	14 9/16	2 13/16	14 9/16

1 1/16" Chain.		1 1/8" Chain.	
P.L. 27 Tons.		P.L. 30 1/4 Tons.	
M.S.	M.I.D.	M.S.	M.I.D.
"	"	"	"
2 1/8	4 1/2	2 1/4	4 13/16
2 3/16	5	2 5/16	5 3/8
2 1/4	5 5/8	2 3/8	5 15/16
2 5/16	6 3/16	2 7/16	6 9/16
2 3/8	6 7/8	2 1/2	7 3/16
2 7/16	7 1/2	2 9/16	7 7/8
2 1/2	8 1/4	2 5/8	8 5/8
2 9/16	9 1/16	2 11/16	9 7/16
2 5/8	9 7/8	2 3/4	10 1/4
2 11/16	10 13/16	2 13/16	11
2 3/4	11 3/4	2 7/8	11 7/8
2 13/16	12 9/16	2 15/16	12 13/16
2 7/8	13 1/2	3	13 3/4
2 15/16	14 9/16	3 1/16	14 3/4
3	15 5/8	3 1/8	15 13/16

TABLE IV.—Proportions of Rings for Three-leg Sling-Chains.

5/16" Chain.		3/8" Chain.		7/16" Chain.	
P.L. 3 1/2 Tons.		P.L. 4 1/2 Tons.		P.L. 6 3/4 Tons.	
M.S.	M.I.D.	M.S.	M.I.D.	M.S.	M.I.D.
"	"	"	"	"	"
15/16	3 5/8	1 1/8	4 5/16	1 5/16	4 15/16
1	4 9/16	1 3/16	5 1/4	1 3/8	5 13/16
1 1/16	5 9/16	1 1/4	6 1/4	1 7/16	6 3/4
1 1/8	6 3/4	1 5/16	7 3/8	1 1/2	7 7/8
1 3/16	8 1/16	1 3/8	8 5/8	1 9/16	9
....	....	1 7/16	9 13/16	1 5/8	10 1/8
....	....	....	....	1 11/16	11 1/4
....	....	....	....	1 3/4	[illegible] 3/8

1/2" Chain		9/16" Chain		5/8" Chain.	
P.L. 9 Tons.		P.L. 11 1/4 Tons.		P.L. 13 3/4 Tons.	
M.S.	M.I.D.	M.S.	M.I.D.	M.S.	M.I.D.
"	"	"	"	"	"
1 1/2	5 1/2	1 11/16	6 1/4	1 7/8	7 1/16
1 9/16	6 3/8	1 3/4	7 1/8	1 15/16	7 7/8
1 5/8	7 5/16	1 13/16	8 1/16	2	8 13/16
1 11/16	8 5/16	1 7/8	9 1/16	2 1/16	9 13/16
1 3/4	9 3/8	1 15/16	10 1/8	2 1/8	10 13/16
1 13/16	10 9/16	2	11 1/4	2 3/16	11 15/16
1 7/8	11 7/8	2 1/16	12 1/2	2 1/4	13 1/8
1 15/16	13 3/16	2 1/8	13 13/16	2 5/16	14 3/8
....	....	2 3/16	15 3/16	2 3/8	15 3/4

TABLE IV. — (*Continued.*)

11/16" Chain.		3/4" Chain.		13/16" Chain.	
P.L. 16 3/4 Tons.		P.L. 20 1/4 Tons.		P.L. 23 7/16 Tons.	
M.S.	M.I.D.	M.S.	M.I.D.	M.S.	M.I.D.
"	"	"	"	"	"
2 1/16	7 13/16	2 1/4	8 1/8	2 7/16	9
2 1/8	8 5/8	2 5/16	8 15/16	2 1/2	9 13/16
2 3/16	9 7/16	2 3/8	9 13/16	2 9/16	10 3/4
2 1/4	10 3/8	2 7/16	10 13/16	2 5/8	11 11/16
2 5/16	11 7/16	2 1/2	11 7/8	2 11/16	12 5/8
2 3/8	12 1/2	2 9/16	13	2 3/4	13 11/16
2 7/16	13 5/8	2 5/8	14	2 13/16	14 3/4
2 1/2	14 13/16	2 11/16	15 3/16	2 7/8	15 7/8
2 9/16	16 1/8	2 3/4	16 3/8	2 15/16	17 1/16
2 5/8	17 7/16	2 13/16	17 5/8	3	18 5/16
....	....	....	....	3 1/16	19 11/16

7/8" Chain.		15/16" Chain.	
P.L. 27 1/4 Tons.		P.L. 31 1/8 Tons.	
M.S.	M.I.D.	M.S.	M.I.D.
"	"	"	"
2 5/8	9 11/16	2 13/16	10 3/8
2 11/16	10 1/2	2 7/8	11 1/4
2 3/4	11 3/8	2 15/16	12 1/16
2 13/16	12 5/16	3	13
2 7/8	13 1/4	3 1/16	14
2 15/16	14 1/4	3 1/8	15
3	15 3/8	3 3/16	16
3 1/16	16 7/16	3 1/4	17 1/8
3 1/8	17 5/8	3 5/16	18 1/4
3 3/16	18 7/8	3 3/8	19 7/16
3 1/4	20 1/8	3 7/16	20 11/16

TABLE V. — Proportions of Rings for Four-leg Sling-Chains.

$\frac{5}{16}''$ Chain.		$\frac{3}{8}''$ Chain.		$\frac{7}{16}''$ Chain.	
P.L. $4\frac{1}{2}$ Tons.		P.L. $6\frac{1}{2}$ Tons.		P.L. 9 Tons.	
M.S.	M.I.D.	M.S	M.I.D.	M.S.	M.I.D.
"	"	"	"	"	"
$1\frac{1}{16}$	$3\frac{15}{16}$	$1\frac{5}{16}$	$5\frac{3}{16}$	$1\frac{1}{2}$	$5\frac{1}{2}$
$1\frac{1}{8}$	$4\frac{13}{16}$	$1\frac{3}{8}$	$6\frac{1}{8}$	$1\frac{9}{16}$	$6\frac{3}{8}$
$1\frac{3}{16}$	$5\frac{3}{4}$	$1\frac{7}{16}$	$7\frac{1}{8}$	$1\frac{5}{8}$	$7\frac{5}{16}$
$1\frac{1}{4}$	$6\frac{7}{8}$	$1\frac{1}{2}$	$8\frac{1}{4}$	$1\frac{11}{16}$	$8\frac{5}{16}$
$1\frac{5}{16}$	$8\frac{1}{16}$	$1\frac{9}{16}$	$9\frac{7}{16}$	$1\frac{3}{4}$	$9\frac{3}{8}$
......	......	......	......	$1\frac{13}{16}$	$10\frac{5}{16}$
......	......	......	......	$1\frac{7}{8}$	$11\frac{3}{8}$

$\frac{1}{2}''$ Chain.		$\frac{9}{16}''$ Chain		$\frac{5}{8}''$ Chain.	
P.L. 12 Tons.		P.L. 15 Tons.		P.L. $18\frac{1}{2}$ Tons.	
M.S.	M.I.D	M.S	M.I.D.	M.S.	M.I.D.
"	"	"	"	"	"
$1\frac{3}{4}$	$6\frac{1}{2}$	$1\frac{13}{16}$	$5\frac{9}{16}$	2	$6\frac{1}{16}$
$1\frac{13}{16}$	$7\frac{7}{16}$	$1\frac{7}{8}$	$6\frac{5}{16}$	$2\frac{1}{16}$	$6\frac{13}{16}$
$1\frac{7}{8}$	$8\frac{3}{8}$	$1\frac{15}{16}$	$7\frac{1}{16}$	$2\frac{1}{8}$	$7\frac{9}{16}$
$1\frac{15}{16}$	$9\frac{3}{8}$	2	8	$2\frac{3}{16}$	$8\frac{1}{2}$
2	$10\frac{9}{16}$	$2\frac{1}{16}$	$8\frac{7}{8}$	$2\frac{1}{4}$	$9\frac{1}{4}$
$2\frac{1}{16}$	$11\frac{9}{16}$	$2\frac{1}{8}$	$9\frac{3}{4}$	$2\frac{5}{16}$	$10\frac{13}{16}$
$2\frac{1}{8}$	$12\frac{13}{16}$	$2\frac{3}{16}$	$10\frac{13}{16}$	$2\frac{3}{8}$	$11\frac{1}{8}$
......	......	$2\frac{1}{4}$	$11\frac{7}{8}$	$2\frac{7}{16}$	$12\frac{3}{16}$
......	......	$2\frac{5}{16}$	$13\frac{1}{16}$	$2\frac{1}{2}$	$13\frac{1}{4}$
......	......	$2\frac{3}{8}$	$14\frac{1}{4}$	$2\frac{9}{16}$	$14\frac{9}{16}$
......	......	......	......	$2\frac{5}{8}$	$15\frac{11}{16}$
......	......	......	......	$2\frac{11}{16}$	$16\frac{15}{16}$

TABLE V. — *(Continued.)*

$\frac{11}{16}''$ Chain.		$\frac{3}{4}''$ Chain.		$\frac{13}{16}''$ Chain.	
P.L. $22\frac{1}{2}$ Tons.		P.L. 27 Tons.		P.L. $31\frac{1}{2}$ Tons.	
M.S.	M.I.D.	M.S.	M.I.D.	M.S.	M.I.D.
"	"	"	"	"	"
$2\frac{3}{16}$	$6\frac{1}{8}$	$2\frac{7}{16}$	$7\frac{1}{2}$	$2\frac{5}{8}$	$8\frac{1}{4}$
$2\frac{1}{4}$	$7\frac{3}{16}$	$2\frac{1}{2}$	$8\frac{1}{4}$	$2\frac{11}{16}$	$8\frac{7}{8}$
$2\frac{5}{16}$	$7\frac{13}{16}$	$2\frac{9}{16}$	$9\frac{1}{16}$	$2\frac{3}{4}$	$9\frac{5}{8}$
$2\frac{3}{8}$	$8\frac{3}{4}$	$2\frac{5}{8}$	$9\frac{7}{8}$	$2\frac{13}{16}$	$10\frac{3}{8}$
$2\frac{7}{16}$	$9\frac{9}{16}$	$2\frac{11}{16}$	$10\frac{11}{16}$	$2\frac{7}{8}$	$11\frac{1}{4}$
$2\frac{1}{2}$	$10\frac{7}{16}$	$2\frac{3}{4}$	$11\frac{3}{4}$	$2\frac{15}{16}$	$12\frac{1}{16}$
$2\frac{9}{16}$	$11\frac{3}{8}$	$2\frac{13}{16}$	$12\frac{9}{16}$	3	13
$2\frac{5}{8}$	$12\frac{3}{8}$	$2\frac{7}{8}$	$13\frac{1}{2}$	$3\frac{1}{16}$	14
$2\frac{11}{16}$	$13\frac{7}{16}$	$2\frac{15}{16}$	$14\frac{9}{16}$	$3\frac{1}{8}$	15
$2\frac{3}{4}$	$14\frac{1}{2}$	3	$15\frac{5}{8}$	$3\frac{3}{16}$	16
$2\frac{13}{16}$	$15\frac{5}{8}$	$3\frac{1}{16}$	$16\frac{11}{16}$	$3\frac{1}{4}$	$17\frac{1}{8}$
$2\frac{7}{8}$	$16\frac{7}{8}$	$3\frac{1}{8}$	18	$3\frac{5}{16}$	$18\frac{1}{4}$
$2\frac{15}{16}$	$18\frac{1}{16}$	$3\frac{3}{16}$	$19\frac{1}{4}$	$3\frac{3}{8}$	$19\frac{7}{16}$
......	......	$3\frac{1}{4}$	$20\frac{9}{16}$	$3\frac{7}{16}$	$20\frac{11}{16}$
......	......	......	......	$3\frac{1}{2}$	22

THE ORDERED LENGTHS OF COUNTERSINK POINT RIVETS.

1. The following curves for ordering countersink point rivets are based on the U. S. Navy standard rivets and countersink. Curves should be read to the longest "ordered length."

2. Where more than two thicknesses are connected, add $\frac{1}{8}''$ to each extra thickness.

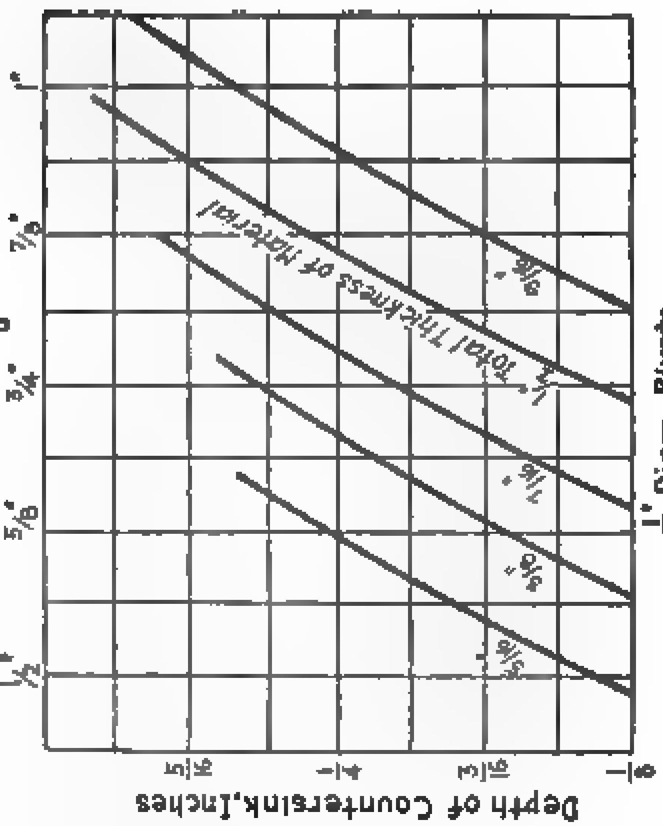
3. Length of snap point rivets use the rule: total thickness of plates + one diam. + $\frac{1}{8}''$; except for excessive thickness, add $\frac{1}{4}''$.

4. For hydraulic riveting add $\frac{1}{8}''$ to the length required for hand or machine work.

5. The curves for $\frac{3}{8}''$ to $\frac{5}{8}''$ rivets are computed $\frac{1}{16}''$, and $\frac{3}{4}''$ to 1" rivets, $\frac{1}{8}''$ longer than required to theoretically fill the hole.

6. The type of head has no bearing on the ordered length.

DIAGRAMS FOR ORDERED LENGTHS OF RIVETS.



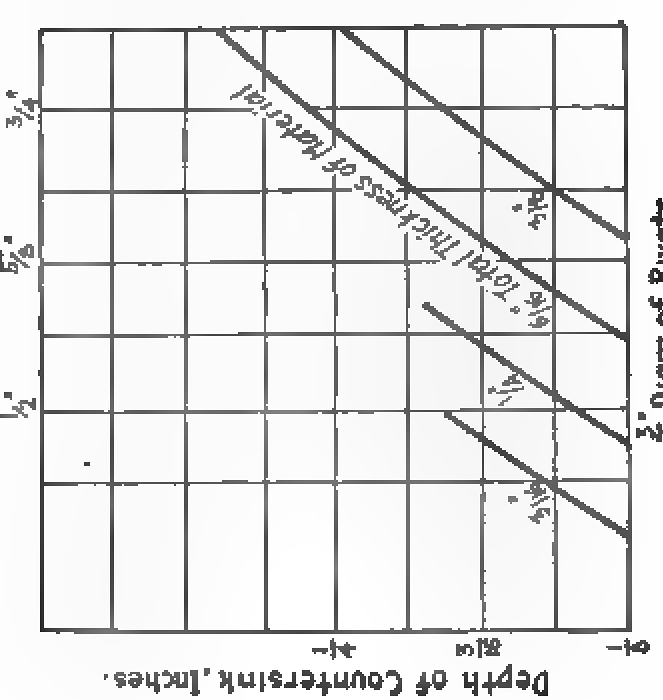
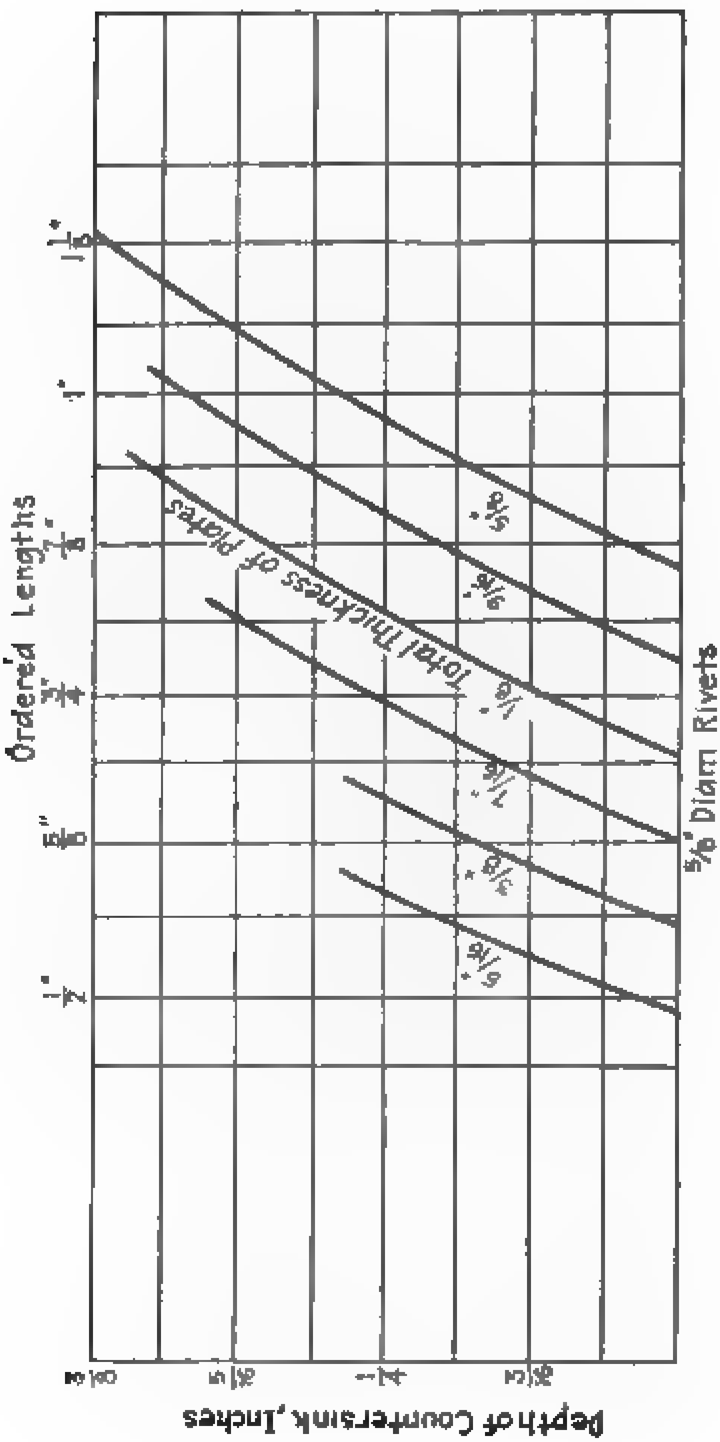


Fig. 284.

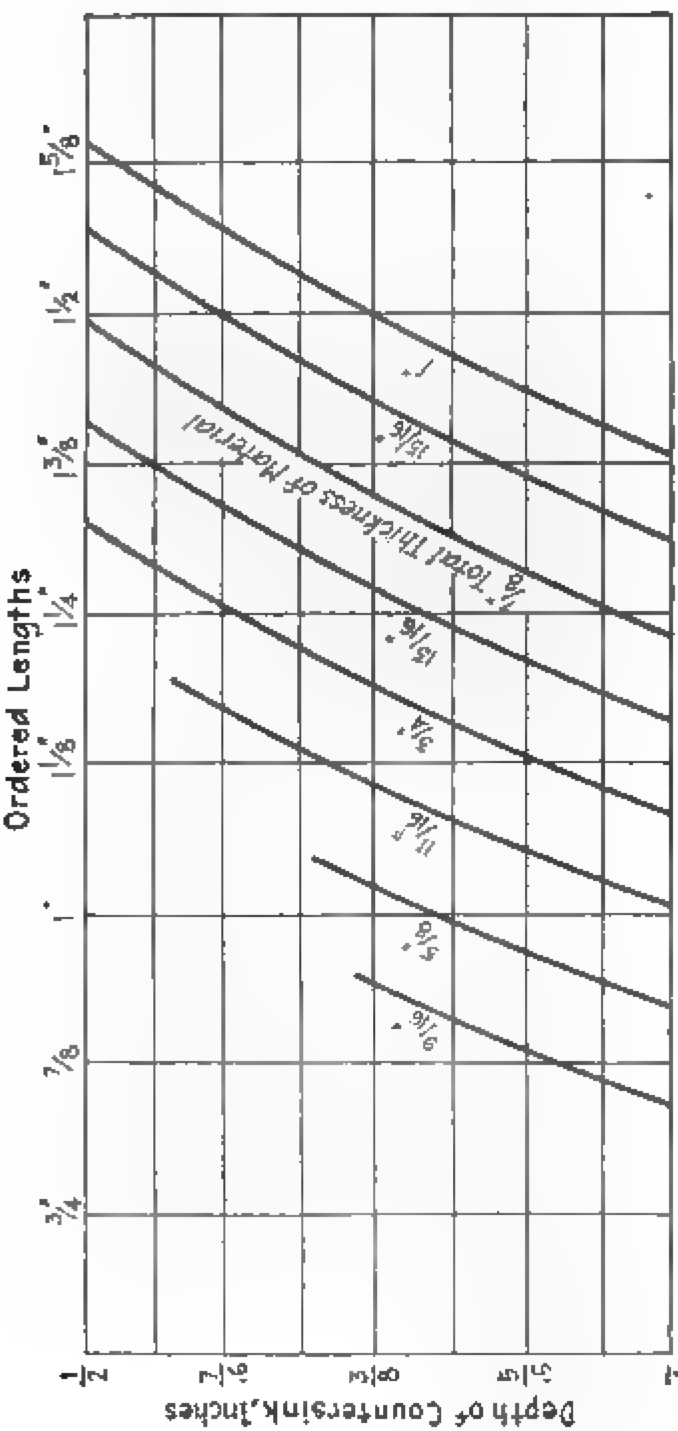
DIAGRAMS FOR ORDERED LENGTHS OF RIVETS.



Exam - Total Thickness of Materials (2 Ply) = 9/16" - Countersink - 1/4" - Ordered Length = 7/8"

FIG. 365.

DIAGRAMS FOR ORDERED LENGTHS OF RIVETS.



3/4" Diam Rivets

Fig. 286.

DIAGRAMS FOR ORDERED LENGTHS OF RIVETS.

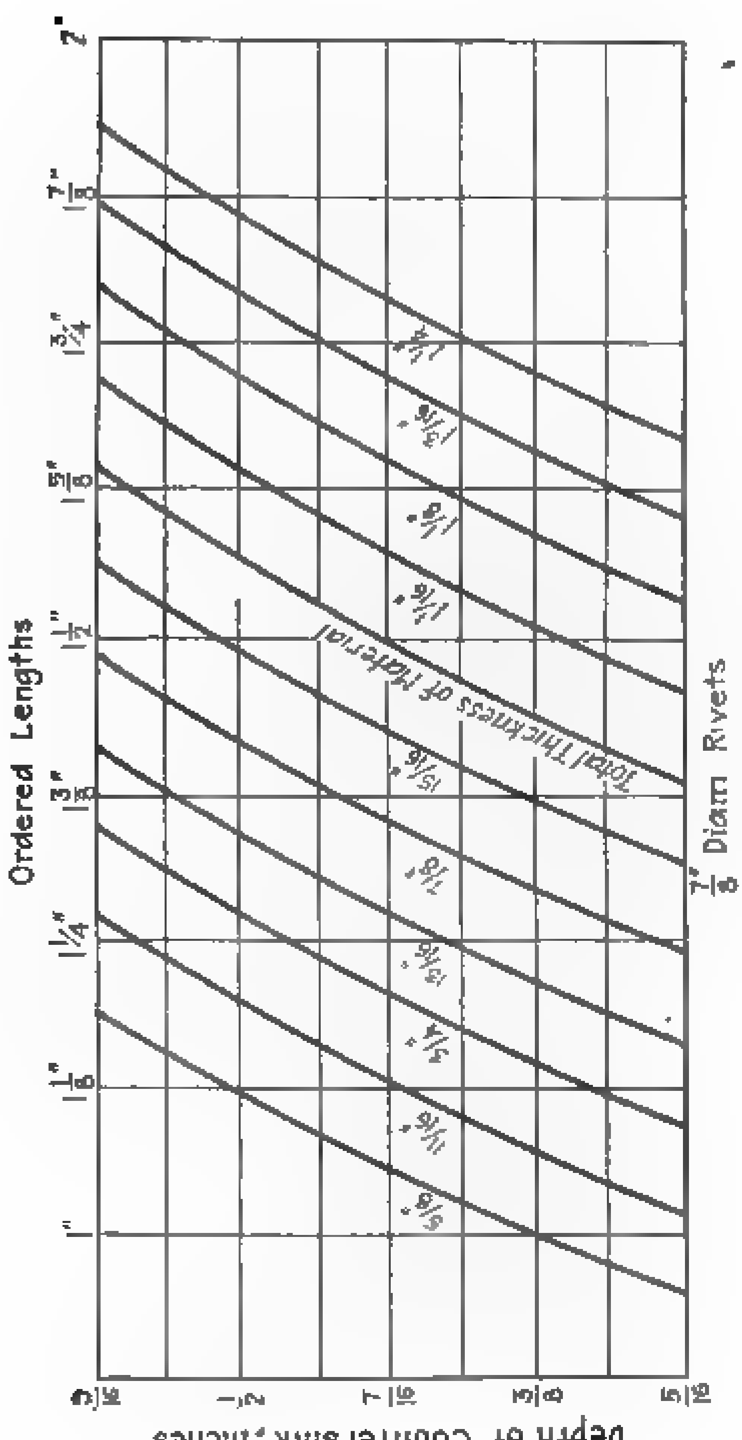
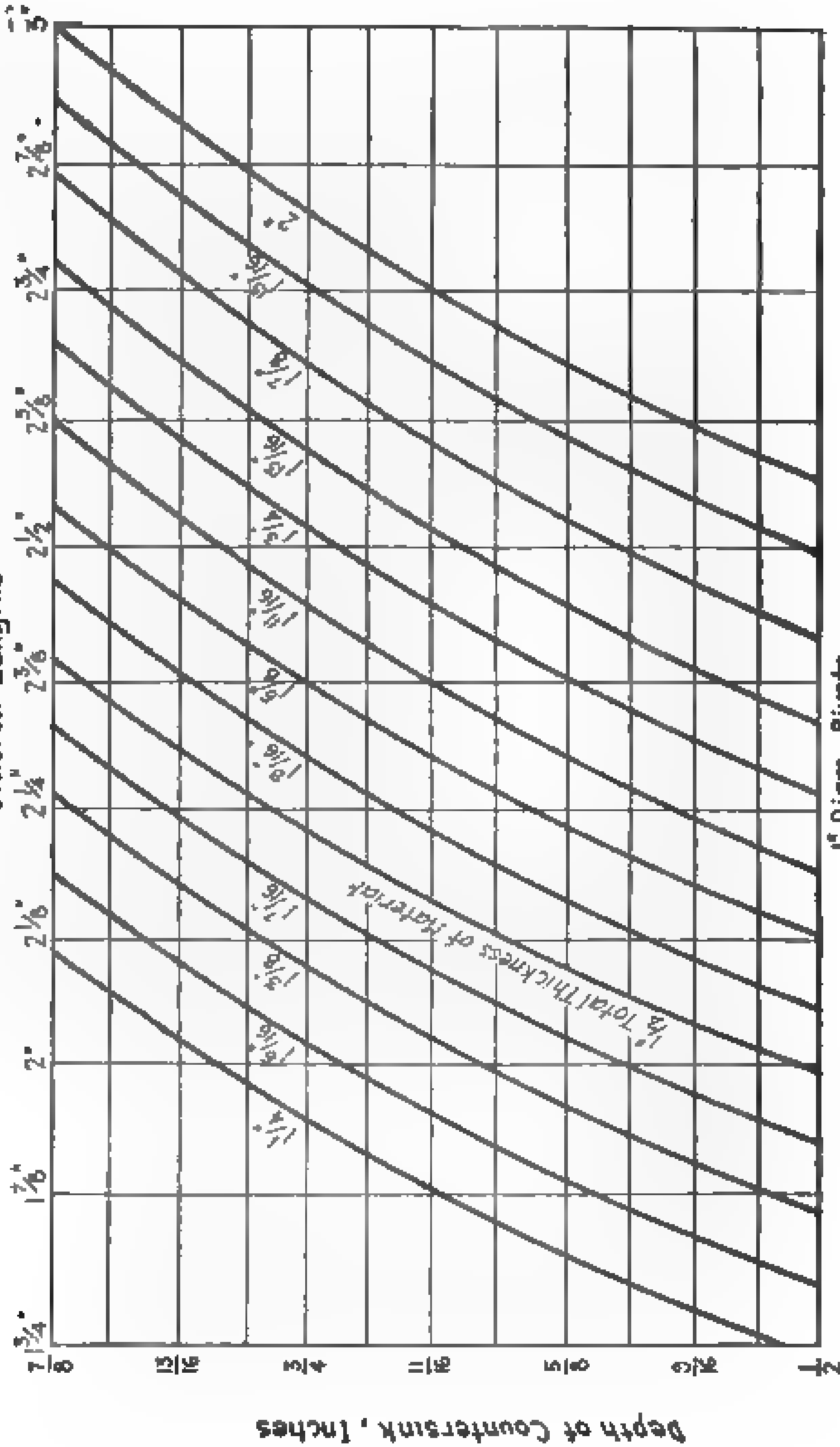


FIG. 287.

DIAGRAMS FOR ORDERED LENGTHS OF RIVETS.



1" Diam. Rivets
Fig. [illegible]

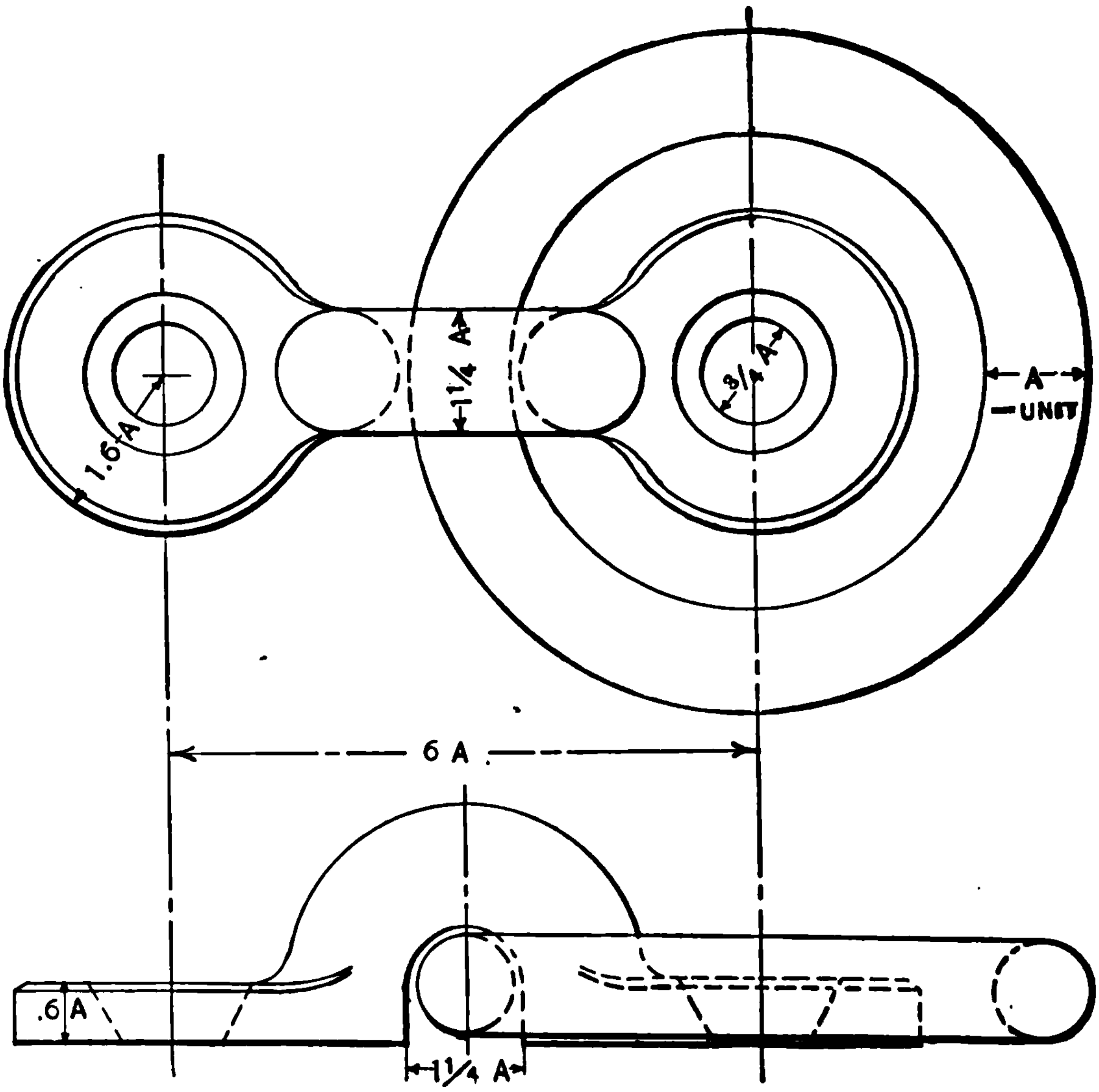


FIG. 289.

DIMENSIONS OF WOOD-CUT SCREW NAILS.

	Iron.				Brass.			
No. of Screw.	Length in Inches.	Wire Gauge.	Dia. in Dec. of In.	Fractional Equivalent.	Length in Inches.	Wire Gauge.	Dia. in Dec. of In.	Fractional Equivalent.
0	[illegible]	17	.058	.	[illegible]	Same as Iron.		
1	[illegible]	15	.071	1/16	[illegible]			
2	[illegible]	14	.084	5/64	[illegible]			
3	[illegible]-1	13	.097	3/32	[illegible]-1 1/4			
4	[illegible]-1 1/2	12	.110	7/64	[illegible]-1 1/2			
5	[illegible]-1 3/4	11	.123	1/8	[illegible]-1 3/4			
6	[illegible]	10	.136	9/64	[illegible]-2			
7	[illegible]	9	.150	5/32	[illegible]-2			
8	[illegible]-4	8	.163	[illegible]	[illegible]-2 1/4			
9	[illegible]-4	7	.176	. . .	[illegible]-2 1/2			
10	[illegible]-4	. .	.189	3/16	[illegible]-3			
11	[illegible]-4	6	.202	13/64	[illegible]-3			
12	[illegible]-5	5	.215	7/32	[illegible]-3			
13	[illegible]-3 1/2	.	.229	. .	[illegible]-3			
14	[illegible]-6	4	.242	15/64	[illegible]-3			
15	[illegible]-3 1/2	3	.255	1/4	[illegible]-3			
16	[illegible]-6	. . .	.268	. .	[illegible]-3			
17	1-3 1/2	2	.281	9/32	1-2 1/2			
18	1-6	1	.294	. . .	1 1/4-3			
20	1-6	0 1/2	.321	. . .	1 1/2-3			
22	1 1/4-6	. . .	.347	11/32	1 3/4-3			
24	1 1/2-6	00	.373	3/8	2-3			
26	3-6	00 1/2	.400	[illegible]	3			
28	4-6	000	.426	7/16	. . .			
30	4 1/2-6	0000	.453	15/32	. . .			

Lengths of Screws Run as Follows:

Iron.—1/4, 3/8, 1/2, 5/8, 3/4, 7/8, 1, 1 1/4, 1 1/2, 1 3/4, 2, 2 1/4, 2 1/2, 2 3/4, 3, 3 1/2, 4, 4 1/2, 5, 6 inches.

Brass.—1/4, 3/8, 1/2, 5/8, 3/4, 7/8, 1, 1 1/4, 1 1/2, 1 3/4, 2, 2 1/4, 2 1/2, 3 inches.

AREAS OF SEA ANCHORS.

FORMULA.—Steamers of 400 tons gross, and under, to have 25 superficial feet of drag anchor, with the addition of 1 square foot for each 25 tons gross above the 400 tons.

Specimen formula for 1,000 tons = $25 + \frac{1{,}000 - 400}{25} = 49$ sf.

Circular Drags.					Square Drags.					Area Drag Required, Vessels 400 to 8,800 Tons.									
Dia.	Area.				Side	Area.				Tons.	Sq. Ft.	Tons	Sq. Ft.	Tons.	Sq. Ft.	Tons.	Sq. Ft.	Tons.	Sq. Ft.
	0	¼	½	¾		0	¼	½	¾										
5	. . .	. . .	23.76	25.97	5	25	27.56	30.25	33.06	400	25	2,100	93	3,800	161	5,500	229	7,200	297
6	28.27	30.68	33.18	35.78	6	36	39.06	42.25	45.56	500	29	2,200	97	3,900	165	5,600	233	7,300	301
7	38.48	41.28	44.18	47.17	7	49	52.56	56.25	60.06	600	33	2,300	101	4,000	169	5,700	237	7,400	305
8	50.27	53.46	56.75	60.13	8	64	68.06	72.25	76.56	700	37	2,400	105	4,100	173	5,800	241	7,500	309
9	63.62	67.20	70.88	74.66	9	81	85.56	90.25	95.06	800	41	2,500	109	4,200	177	5,900	245	7,600	313
10	78.54	82.52	86.59	90.76	10	100	105.06	110.25	115.56	900	45	2,600	113	4,300	181	6,000	249	7,700	317
11	95.03	99.40	103.86	108.43	11	121	126.56	132.25	138.06	1,000	49	2,700	117	4,400	185	6,100	253	7,800	321
12	113.10	117.86	122.72	127.68	12	144	150.06	156.25	162.56	1,100	53	2,800	121	4,500	189	6,200	257	7,900	325
13	132.73	137.89	143.14	148.49	13	169	175.56	182.25	189.06	1,200	57	2,900	125	4,600	193	6,300	261	8,000	329
14	153.94	159.49	165.13	170.87	14	196	203.06	210.25	217.56	1,300	61	3,000	129	4,700	197	6,400	265	8,100	333
15	176.72	182.66	188.69	194.83	15	225	232.56	240.25	248.06	1,400	65	3,100	133	4,800	201	6,500	269	8,200	337
16	201.06	207.40	213.83	220.35	16	256	264.06	272.25	280.56	1,500	69	3,200	137	4,900	205	6,600	273	8,300	341
17	226.98	233.71	240.53	247.45	17	289	297.56	306.25	315.06	1,600	73	3,300	141	5,000	209	6,700	277	8,400	345
18	254.47	261.59	268.80	276.12	18	324	333.06	342.25	351.56	1,700	77	3,400	145	5,100	213	6,800	281	8,500	349
19	283.53	291.04	298.64	306.36	19	361	370.56	380.25	390.00	1,800	81	3,500	149	5,200	217	6,900	285	8,600	353
20	314.16	322.06	330.06	338.16	20	400	410.06	420.25	430.56	1,900	85	3,600	153	5,300	221	7,000	289	8,700	357
										2,000	89	3,700	157	5,400	225	7,100	293	8,800	361

Based on paragraph 17, page 51 in the January, 1901, edition of Rules by Board of Supervising Inspectors of Steam Vessels.

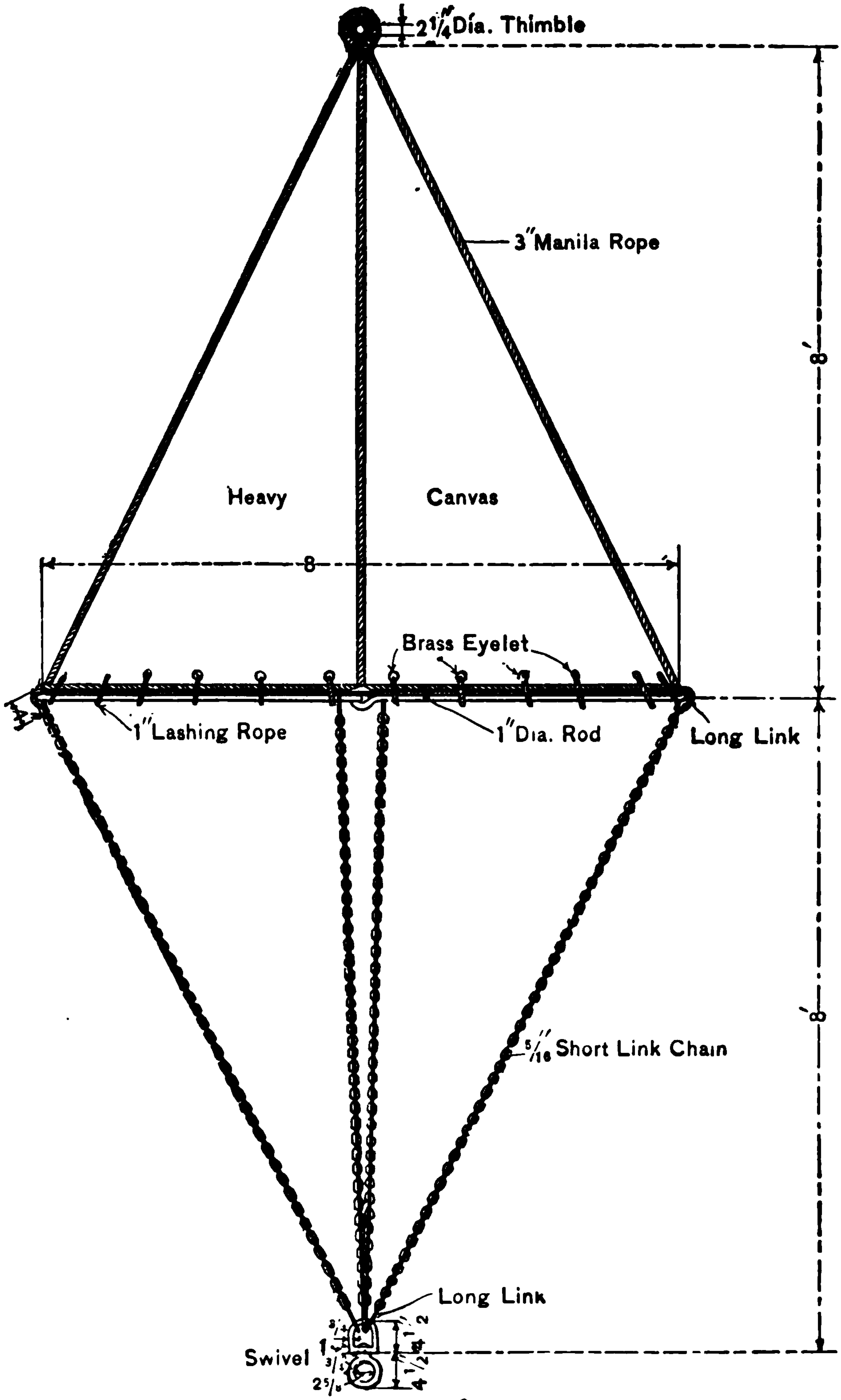

2 1/4" Dia. Thimble
3" Manila Rope
8'
Heavy
Canvas
8'
Brass Eyelet
1" Lashing Rope
1" Dia. Rod
Long Link
5/16" Short Link Chain
8'
Long Link
Swivel

FIG. 290.

STANDARD SHACKLES (As Manufactured).

Anchor Shackles.

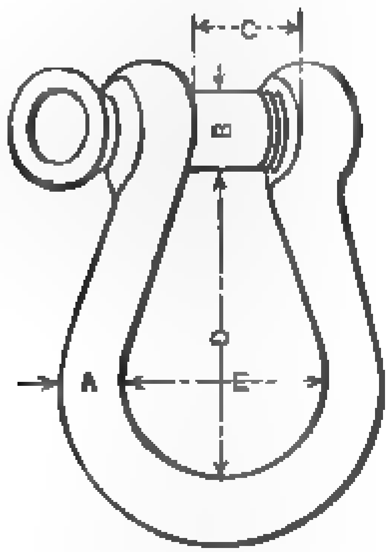


FIG. 291.

SIZE OF SHACKLE, *A*.	SIZE OF PIN, *B*.	OPENING AT EYE, *C*.	DEPTH UNDER PIN INSIDE, *D*.	WIDTH OF SWELL INSIDE, *E*.
"	"	"	"	"
$\frac{1}{4}$	$\frac{5}{16}$	$\frac{1}{2}$	$1\frac{1}{8}$	$\frac{13}{16}$
$\frac{5}{16}$	$\frac{3}{8}$	$\frac{5}{8}$	$1\frac{1}{4}$	1
$\frac{3}{8}$	$\frac{7}{16}$	$\frac{11}{16}$	$1\frac{1}{2}$	1 [illegible]
$\frac{7}{16}$	$\frac{1}{2}$	$\frac{3}{4}$	$1\frac{3}{4}$	1 [illegible]
$\frac{1}{2}$	$\frac{9}{16}$	$\frac{7}{8}$	$2\frac{1}{8}$	1 [illegible]
$\frac{9}{16}$	$\frac{5}{8}$	1	$2\frac{1}{2}$	1 [illegible]
$\frac{5}{8}$	$\frac{3}{4}$	$1\frac{1}{8}$	$2\frac{3}{4}$	2
$\frac{3}{4}$	$\frac{7}{8}$	$1\frac{1}{4}$	3	$2\frac{1}{8}$
$\frac{7}{8}$	1	$1\frac{3}{8}$	$3\frac{1}{4}$	2 [illegible]
1	$1\frac{1}{8}$	$1\frac{5}{8}$	$3\frac{3}{4}$	2 [illegible]
$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{4}$	4	2 [illegible]
$1\frac{1}{4}$	$1\frac{3}{8}$	2	$4\frac{1}{4}$	3 [illegible]
$1\frac{3}{8}$	$1\frac{1}{2}$	$2\frac{1}{4}$	$4\frac{3}{4}$	3 [illegible]
$1\frac{1}{2}$	$1\frac{5}{8}$	$2\frac{1}{2}$	6	3 [illegible]
$1\frac{5}{8}$	$1\frac{3}{4}$	$2\frac{3}{4}$	$6\frac{1}{2}$	4 [illegible]
$1\frac{3}{4}$	$1\frac{7}{8}$	3	7	4 [illegible]
$1\frac{7}{8}$	2	$3\frac{1}{4}$	$7\frac{1}{4}$	5
2	$2\frac{1}{8}$	$3\frac{1}{2}$	$7\frac{3}{4}$	$5\frac{1}{4}$

SISTERHOOKS.

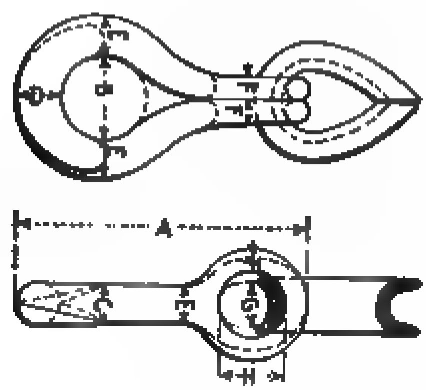


FIG. 202.

d	$a=6.5\,d.$	$b=2\,d.$	$c=0.9\,d.$	$e=0.75\,d.$	$f=0.5\,d$	$g=d.$	$h=1.5\,d.$	Testload in Lbs. $P=4260\,d^2.$	No. of Thimble.
″	″	″	″	″	″	″	″		
$\frac{3}{8}$	$2\frac{1}{2}$	$\frac{3}{4}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{3}{8}$	$\frac{9}{16}$	600	10
$\frac{1}{2}$	$3\frac{5}{16}$	1	$\frac{7}{16}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	1065	12
$\frac{5}{8}$	$4\frac{1}{8}$	$1\frac{1}{4}$	$\frac{9}{16}$	$\frac{1}{2}$	$\frac{5}{16}$	$\frac{5}{8}$	$\frac{15}{16}$	1660	12
$\frac{3}{4}$	$4\frac{15}{16}$	$1\frac{1}{2}$	$\frac{11}{16}$	$\frac{9}{16}$	$\frac{3}{8}$	$\frac{3}{4}$	$1\frac{1}{8}$	2390	14
$\frac{7}{8}$	$5\frac{3}{4}$	$1\frac{3}{4}$	$\frac{13}{16}$	$\frac{5}{8}$	$\frac{7}{16}$	$\frac{7}{8}$	$1\frac{5}{16}$	3260	16
1	$6\frac{5}{8}$	2	$\frac{15}{16}$	$\frac{3}{4}$	$\frac{1}{2}$	1	$1\frac{1}{2}$	4260	18
$1\frac{1}{8}$	$7\frac{7}{16}$	$2\frac{1}{4}$	1	$\frac{7}{8}$	$\frac{9}{16}$	$1\frac{1}{8}$	$1\frac{11}{16}$	5390	20
$1\frac{1}{4}$	$8\frac{1}{4}$	$2\frac{1}{2}$	$1\frac{1}{8}$	$\frac{15}{16}$	$\frac{5}{8}$	$1\frac{1}{4}$	$1\frac{7}{8}$	6650	20

SLIP SHACKLES.

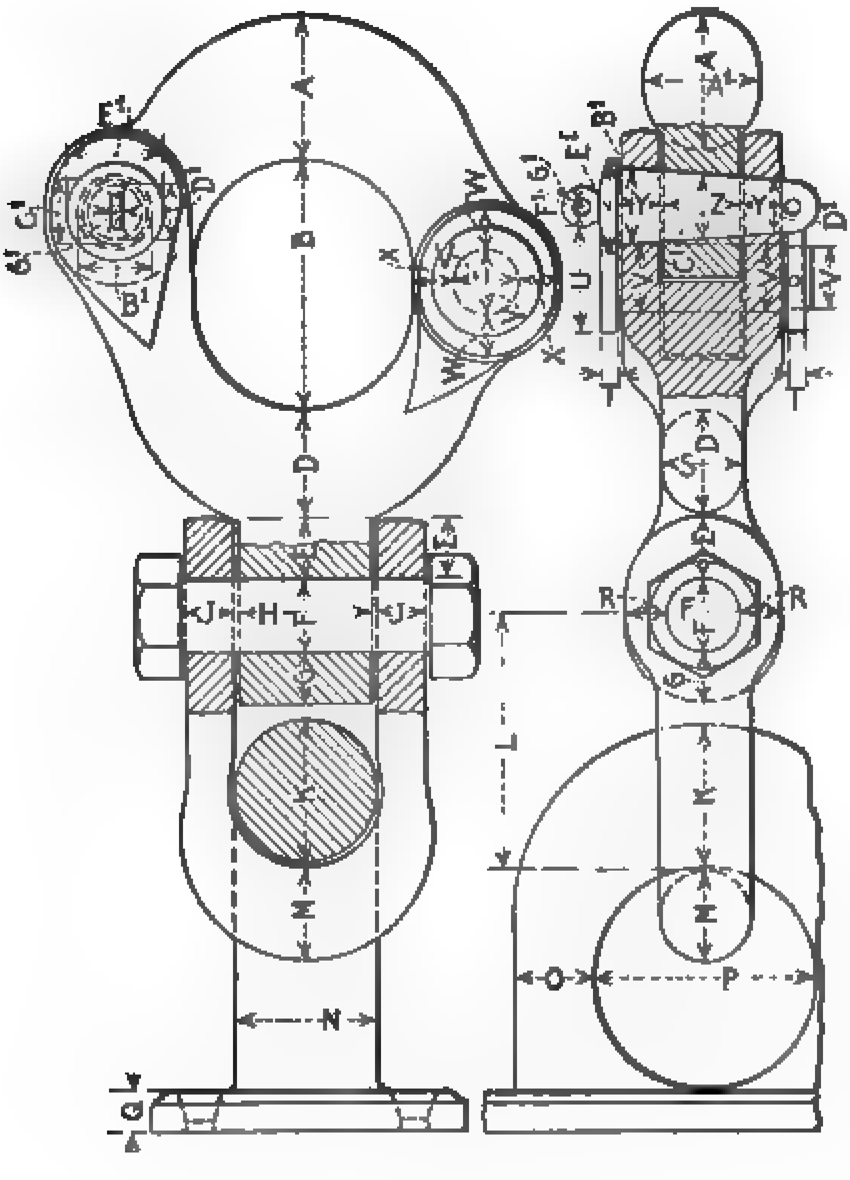


Fig. 268.

SLIP SHACKLES.

W. Load (Fac. of Safety 5).	A.	B.	C.	D.	E.	F.	G.	H.	J.	K.
65 tons ..	4	10	10	4	$2\frac{3}{8}$	$2\frac{1}{2}$	$2\frac{3}{8}$	6	$1\frac{1}{2}$	$5\frac{1}{2}$
100 tons...	$4\frac{3}{8}$	9	8	$3\frac{5}{8}$	[illegible]$\frac{1}{8}$	$2\frac{5}{8}$	$4\frac{7}{8}$	5	$1\frac{3}{4}$	5
150 tons...	$5\frac{5}{8}$	9	8	$4\frac{1}{8}$	$2\frac{1}{8}$	3	$2\frac{1}{8}$	$5\frac{1}{4}$	$1\frac{7}{8}$	5
200 tons...	$6\frac{1}{4}$	10	$8\frac{5}{8}$	$4\frac{1}{2}$	$2\frac{1}{4}$	$3\frac{1}{2}$	$2\frac{1}{2}$	6	2	$5\frac{1}{2}$

W. Load (Fac. of Safety 5)	L.	M.	N.	O.	P.	Q.	R.	S.	T	U	V.
65 tons.	$10\frac{3}{4}$	$3\frac{1}{4}$	$5\frac{1}{2}$	3	9	$1\frac{1}{2}$	$1\frac{3}{8}$	4	$\frac{3}{4}$	$3\frac{3}{4}$	$2\frac{1}{4}$
100 tons	$8\frac{3}{4}$	$3\frac{1}{4}$	5	$2\frac{3}{8}$	8	$1\frac{1}{2}$	$1\frac{1}{2}$	3	$\frac{3}{4}$	$3\frac{3}{4}$	$2\frac{1}{4}$
150 tons	10	$3\frac{3}{4}$	5	$2\frac{3}{4}$	8	$1\frac{1}{2}$	$1\frac{5}{8}$	$3\frac{1}{2}$	$\frac{7}{8}$	4	$2\frac{1}{2}$
200 tons.	$11\frac{1}{2}$	4	$5\frac{1}{2}$	3	9	$1\frac{1}{2}$	$1\frac{3}{4}$	4	$\frac{7}{8}$	$4\frac{1}{2}$	$2\frac{3}{4}$

W. Load (Fac. of Safety 5).	W.	X.	Y.	Z.	A1	B1.	C1	D1.	E1.	F1.	G1.
65 tons.	$1\frac{5}{16}$	$1\frac{5}{16}$	$1\frac{1}{2}$	$2\frac{1}{4}$	4	$2\frac{1}{2}$	$2\frac{1}{4}$	2	$3\frac{1}{4}$	$\frac{5}{8}$	$\frac{1}{2}$
100 tons.	$1\frac{1}{2}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$2\frac{7}{8}$	$4\frac{7}{8}$	$2\frac{5}{8}$	$2\frac{3}{8}$	$2\frac{1}{8}$	$3\frac{3}{8}$	$\frac{5}{8}$	$\frac{3}{4}$
150 tons.	$1\frac{5}{8}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$3\frac{1}{4}$	$4\frac{3}{4}$	$2\frac{7}{8}$	$2\frac{1}{2}$	$2\frac{1}{8}$	$3\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$
200 tons.	$1\frac{3}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	$3\frac{7}{8}$	$5\frac{1}{8}$	$3\frac{1}{8}$	$2\frac{3}{4}$	$2\frac{3}{8}$	$4\frac{1}{8}$	$\frac{7}{8}$	$\frac{7}{8}$

STANDARD SHACKLES (As Manufactured).
(Continued.)

Chain Shackles.

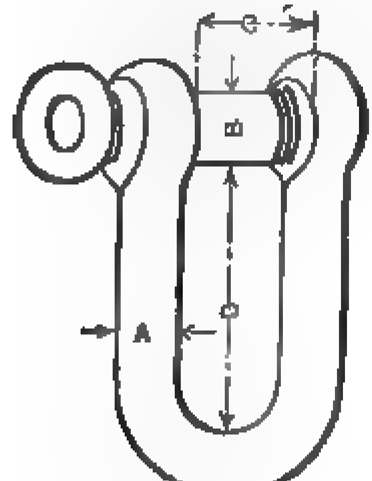


FIG. 294.

SIZE OF SHACKLE, *A*.	SIZE OF PIN, *B*.	OPENING AT EYE, *C*.	DEPTH UNDER PIN INSIDE, *D*.
″	″	″	″
1/4	5/16	7/16	7/8
5/16	3/8	1/2	1
3/8	7/16	9/16	1 1/8
7/16	1/2	5/8	1 5/16
1/2	9/16	3/4	1 1/2
9/16	5/8	15/16	1 7/8
5/8	3/4	1 1/16	2
3/4	7/8	1 1/8	2 1/4
7/8	1	1 1/4	2 5/16
1	1 1/8	1 3/8	3
1 1/8	1 1/4	1 1/2	3 3/4
1 1/4	1 3/8	1 5/8	4 1/8
1 3/8	1 1/2	1 7/8	4 5/8
1 1/2	1 5/8	2	5 1/4
1 5/8	1 3/4	2 1/8	5 5/8
1 3/4	1 7/8	2 1/4	6
1 7/8	2	2 1/2	6 1/2
2	2 1/8	2 3/4	7

STANDARD SHACKLES.

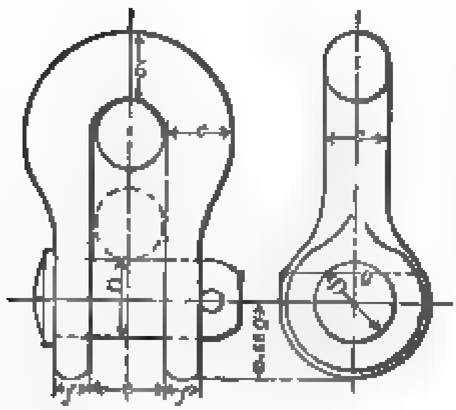


FIG. 295.

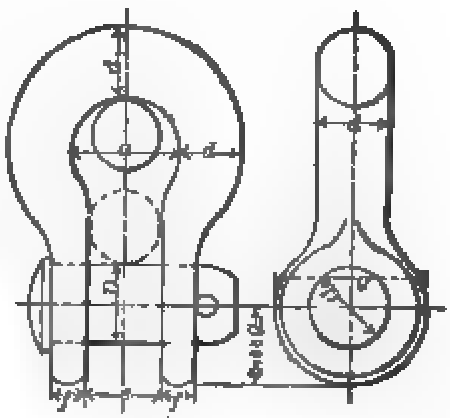


FIG. 296.

BREAKING LOAD IN POUNDS.	SHACKLES.								
	Bow in Clear.	Iron at Sides	Iron at Bow.	Iron at Sides.	Iron at Bow.	Dia. of Pin.	Jaws in Clear.	Thickness of Eye.	Eye Outside Dia.
	a.	d.	d_1.	c.	c_1.	D.	e.	f.	g
	"	"	"	"	"	"	"	"	"
9,000	1	5/16	5/16	3/8	5/16	9/16	3/4	1/4	1
9,000- 11,000	1 3/16	7/16	9/16	1/2	7/16	5/8	7/8	5/16	1 1/16
11,000- 16,500	1 3/8	1/2	11/16	9/16	1/2	5/8	15/16	3/8	1 3/16
15,500- 20,000	1 7/16	11/16	13/16	5/8	5/8	3/4	1	3/8	1 5/16
20,000- 24,000	1 1/2	3/4	7/8	11/16	3/4	13/16	1 1/16	7/16	1 1/2
24,000- 31,000	1 11/16	7/8	15/16	3/4	13/16	7/8	1 1/8	7/16	1 3/4
31,000- 37,500	1 3/4	15/16	1 1/16	13/16	7/8	1 1/16	1 3/16	1/2	2 1/16
37,500- 44,000	1 7/8	1 1/16	1 1/8	7/8	15/16	1 1/8	1 1/4	1/2	2 1/4
44,000- 53,000	1 15/16	1 1/8	1 1/4	15/16	1 1/16	1 3/16	1 5/16	9/16	2 3/8
53,000- 62,000	2	1 3/16	1 5/16	1 1/16	1 1/8	1 5/16	1 3/8	9/16	2 1/2
62,000- 70,500	2 1/16	1 1/4	1 3/8	1 1/8	1 1/4	1 7/16	1 7/16	5/8	2 11/16
70,500- 79,500	2 3/16	1 5/16	1 7/16	1 1/8	1 1/4	1 1/2	1 1/2	5/8	2 13/16
79,500- 88,000	2 1/4	1 3/8	1 1/2	1 1/4	1 5/16	1 9/16	1 9/16	11/16	3
88,000- 99,000	2 5/16	1 7/16	1 9/16	1 5/16	1 3/8	1 5/8	1 9/16	11/16	3 1/8
99,000- 110,000	2 3/8	1 7/16	1 5/8	1 5/16	1 7/16	1 11/16	1 5/8	3/4	3 3/16
110,000- 121,000	2 7/16	1 1/2	1 11/16	1 3/8	1 1/2	1 3/4	1 11/16	13/16	3 5/16
121,000- 132,500	2 1/2	1 9/16	1 11/16	1 7/16	1 9/16	1 13/16	1 3/4	13/16	3 7/16
132,500- 143,500	2 1/2	1 5/8	1 3/4	1 1/2	1 5/8	1 7/8	1 13/16	7/8	3 5/8
143,500- 154,500	2 9/16	1 11/16	1 13/16	1 9/16	1 11/16	1 15/16	1 13/16	7/8	3 3/4
154,500- 165,500	2 5/8	1 11/16	1 7/8	1 9/16	1 3/4	2	1 7/8	15/16	3 7/8
165,500- 176,500	2 5/8	1 3/4	2	1 5/8	1 13/16	2 1/16	1 15/16	1	4
176,500- 187,500	2 11/16	1 13/16	2	1 11/16	1 7/8	2 1/8	2	1 1/16	4 1/16
187,500- 198,500	2 11/16	1 7/8	2 1/16	1 3/4	1 7/8	2 3/16	2	1 1/16	4 3/16
198,500- 210,000	2 3/4	1 7/8	2 1/16	1 3/4	2	2 1/4	2 1/16	1 1/8	4 5/16
210,000- 221,000	2 13/16	1 15/16	2 1/8	1 13/16	2	2 5/16	2 1/16	1 3/16	4 7/16
221,000- 245,000	2 7/8	2	2 3/16	1 7/8	2 1/4	2 3/8	2 1/8	1 1/4	4 9/16

WORKED EYES.

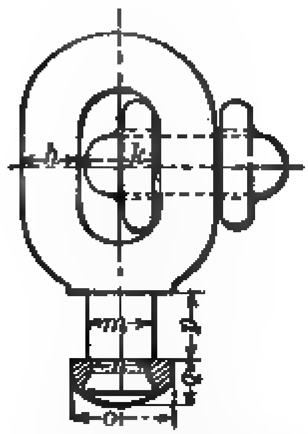


Fig. 297.

Breaking Load in Pounds.	Worked Eyes.						
	Wire.	Clear.					
	h.	k.	m.	n.	o.	p.	q.
	"	"	"	"	"	"	"
9,000	5/16	1	9/16	5/16	1	9/16	7/16
9,000– 11,000	9/16	1 1/8	5/8	9/16	1 1/8	5/8	1/2
11,000– 15,500	5/8	1 1/8	11/16	5/8	1 1/8	3/4	1/2
15,500– 20,000	11/16	1 1/4	3/4	11/16	1 1/4	13/16	9/16
20,000– 24,000	3/4	1 5/16	13/16	3/4	1 3/8	7/8	5/8
24,000– 31,000	13/16	1 3/8	7/8	13/16	1 1/2	1 1/16	5/8
31,000– 37,500	7/8	1 7/16	1	7/8	1 5/8	1 1/8	11/16
37,500– 44,000	15/16	1 1/2	1 1/16	1	1 13/16	1 3/16	3/4
44,000– 53,000	1 1/16	1 5/8	1 1/8	1 1/16	1 15/16	1 1/4	13/16
53,000– 62,000	1 1/16	1 5/8	1 3/16	1 1/8	2 1/16	1 5/16	7/8
62,000– 70,500	1 1/8	1 3/4	1 1/4	1 3/16	2 3/16	1 7/16	15/16
70,500– 79,500	1 3/16	1 13/16	1 5/16	1 1/4	2 3/8	1 1/2	1
79,000– 88,000	1 1/4	1 7/8	1 7/16	1 5/16	2 1/2	1 9/16	1 1/16
88,000– 99,000	1 5/16	2	1 1/2	1 7/16	2 5/8	1 11/16	1 1/8
99,000–110,000	1 3/8	2	1 9/16	1 1/2	2 3/4	1 3/4	1 1/8
110,000–121,000	1 7/16	2 1/16	1 11/16	1 9/16	2 7/8	1 13/16	1 3/16
121,000–132,500	1 1/2	2 1/8	1 11/16	1 11/16	3 1/16	1 7/8	1 1/4
132,500–143,500	1 9/16	2 3/16	1 7/8	1 11/16	3 1/8	1 15/16	1 5/16
143,500–154,500	1 5/8	2 3/16	1 15/16	1 3/4	3 1/4	2 1/16	1 5/16
154,500–165,500	1 11/16	2 1/4	2 1/16	1 7/8	3 3/8	2 1/8	1 7/16
165,500–176,500	1 11/16	2 5/16	2 1/16	1 7/8	3 1/2	2 3/16	1 7/16
176,500–187,500	1 3/4	2 5/16	2 3/16	2	3 5/8	2 1/4	1 1/2
187,500–198,500	1 13/16	2 3/8	2 3/16	2	3 3/4	2 3/8	1 9/16
198,500–210,000	1 7/8	2 3/8	2 1/4	2 1/16	3 7/8	2 7/16	1 5/8
210,000–221,000	1 7/8	2 7/16	2 3/8	2 1/16	3 15/16	2 1/2	1 11/16
221,000–245,000	2	2 1/2	2 1/2	2 1/8	4	2 9/16	1 3/4

TOWING BITTS. (Cast Iron.)

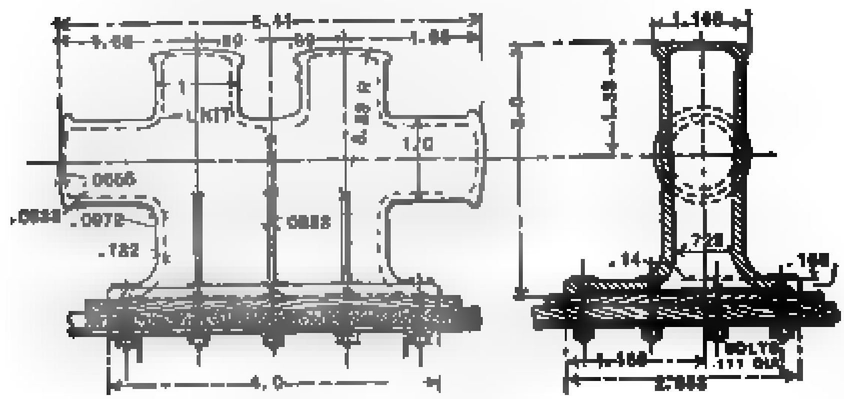
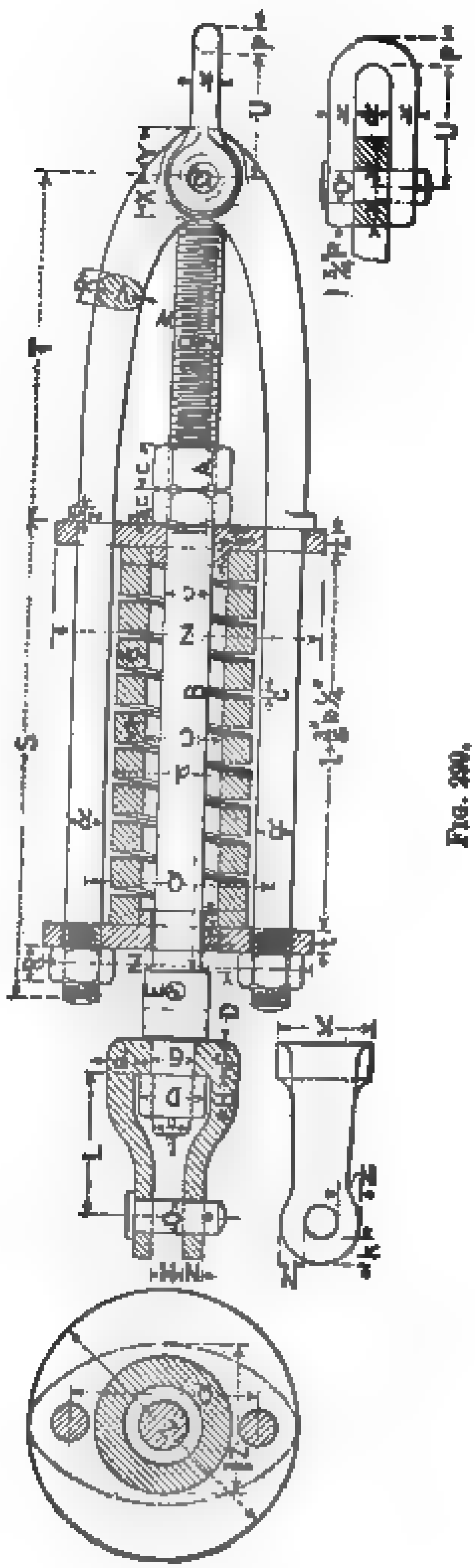


FIG. 296.

DIAMETER.	WEIGHT OF CASTING.	WEIGHT OF FASTENINGS AND CHOCK.	TOTAL WEIGHT.
In.	Lbs.	Lbs.	Lbs.
12	2,040	145	2,185
15	3,975	280	4,255
18	6,875	480	7,355
21	10,900	765	11,665
24	16,500	1,140	17,640



STEERING CHAIN SPRINGS.

FIG. 280.

STEERING CHAIN SPRINGS.

No	Dimensions of Chain.	Working Load.	Dimensions of Parts.																										Dimensions of Spring. Square Bar.	Diameter. Inside.	Diameter. Outside.	Expanded. Length.	Expanded. Distance between Coils.
	k	Tons	A	B	C	D	E	F	G	H	I	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	t	a	d	b	l	c
	″		″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″
1	1/2	1 6	9	12 1/4	7/8	1 1/8	3/8	3/4	3/4	1/2	1/2	2	2 3/8	5/8	1/4	1/2	9/16	4	5/8	12 3/4	10 1/4	2 1/8	1	1 1/4	3/4	1	6	1/2	1/2	1 1/2	3	10 1/4	3/16
2	9/16	2 0	9 1/4	12 3/4	1	1 1/8	3/8	3/4	1	1/2	5/8	2 1/4	3	11/16	1/4	11/16	5/8	4 3/8	5/8	13 1/4	10 1/2	2 1/4	1 1/16	1 1/4	3/4	1	6 1/4	5/8	11/16	1 5/8	3 1/4	11 1/4	7/32
3	5/8	2 5	9 1/2	13 1/4	1 1/4	1 1/4	3/8	3/4	1 1/16	1/2	5/8	2 3/8	3 1/4	5/8	1/4	3/4	11/16	4 1/2	5/8	14	10 3/4	2 3/8	1 3/16	1 3/8	7/8	1 1/8	7	11/16	3/4	2	3 3/8	11 1/2	7/32
4	11/16	3 0	9 3/4	13 3/4	1 3/8	1 3/8	3/8	1	1 3/16	5/8	1	2 1/2	3 3/4	13/16	5/16	13/16	3/4	5 1/4	3/4	14 1/2	11 1/4	3 1/4	1 1/4	1 7/16	1	1 1/4	7 1/2	11/16	13/16	2 1/4	3 3/4	12	1/4
5	3/4	3 6	10	14 1/4	1 1/2	2	1/2	1 1/8	1 1/4	5/8	1 1/16	2 13/16	4	7/8	5/16	13/16	13/16	5 1/2	1	15 1/4	11 1/2	3 1/2	1 5/16	1 5/16	1 1/8	1 1/4	8	3/4	7/8	2 3/8	4 1/8	12 1/4	9/32
6	13/16	4 2	10 1/4	14 3/4	1 5/8	2 1/8	1/2	1 1/4	1 5/16	3/4	1 1/8	3	4 1/4	15/16	3/8	1	7/8	5 3/4	1 1/8	15 3/4	11 3/4	3 3/4	1 3/8	1 11/16	1 1/4	1 3/8	8 1/4	3/4	15/16	2 1/2	4 3/8	12 3/4	9/32
7	7/8	4 9	10 1/2	15 1/4	1 5/8	2 1/4	1/2	1 1/4	1 7/16	3/4	1 1/4	3 1/4	4 1/2	1	3/8	1 1/16	15/16	6 1/4	1 1/8	16 1/4	12 1/4	4	1 1/2	1 3/4	1 3/8	1 1/2	9	13/16	1	2 1/2	4 5/8	13 1/4	19/64
8	15/16	5 6	10 3/4	15 3/4	1 3/4	2 3/8	1/2	1 3/8	1 1/2	1	1 5/16	3 3/8	4 3/4	1 1/16	3/8	1 1/8	1	6 1/2	1 1/4	16 3/4	12 3/4	4 1/4	1 5/8	1 7/8	1 3/8	1 5/8	9 1/2	13/16	1 1/16	2 1/2	4 7/8	13 3/4	5/16
9	1	6 4	11	16 1/4	1 3/4	2 1/2	5/8	1 3/8	1 5/8	1	1 3/8	3 1/2	4 3/4	1 1/8	7/16	1 3/16	1 1/16	6 3/4	1 1/4	17 1/4	13	4 1/2	1 3/4	2	1 1/2	1 3/4	10	7/8	1 1/8	2 3/4	5 1/8	14 1/4	5/16
10	1 1/16	7 2	11 1/4	16 3/4	1 7/8	2 5/8	5/8	1 1/2	1 3/4	1 1/8	1 1/2	3 3/4	5	1 3/16	7/16	1 1/4	1 1/8	7 1/4	1 3/8	18	13 1/4	4 3/4	1 7/8	2 1/8	1 1/2	1 7/8	10 1/2	7/8	1 3/16	3	5 3/8	14 3/4	11/32
11	1 1/8	8 1	11 1/2	17 1/4	2	2 3/4	5/8	1 1/2	1 7/8	1 1/4	1 1/2	4	5 1/4	1 1/4	1/2	1 5/16	1 3/16	7 1/2	1 3/8	18 1/2	13 3/4	4 7/8	2	2 3/16	1 5/8	2	11	15/16	1 1/4	3 1/8	5 1/2	15	3/8
12	1 3/16	9 0	11 3/4	17 3/4	2	2 7/8	5/8	1 5/8	1 7/8	1 1/4	1 9/16	4 1/4	5 1/2	1 5/16	1/2	1 7/16	1 1/4	7 3/4	1 1/2	19 1/4	14 1/4	5 1/4	2 1/8	2 1/4	1 3/4	2 1/8	11 1/2	15/16	1 5/16	3 1/4	6	15 1/2	3/8
13	1 1/4	10 0	12	18 1/4	2 1/8	2 7/8	3/4	1 5/8	2	1 3/8	1 5/8	4 1/2	5 3/4	1 3/8	1/2	1 1/2	1 5/16	8 1/4	1 1/2	19 3/4	14 1/2	5 1/2	2 3/16	2 3/8	2	2 1/4	12	1	1 3/8	3 3/8	6 1/4	16	3/8
14	1 5/16	12 1	12 1/4	19 1/4	2 1/4	3	3/4	2	2 1/8	1 3/8	1 3/4	4 3/4	6	1 1/2	1/2	1 9/16	1 3/8	8 3/4	1 5/8	20 1/4	15 1/4	5 3/4	2 1/4	2 1/2	2 1/8	2 3/8	12 1/2	1 1/16	1 7/16	3 1/2	6 5/8	16 1/2	13/32
15	1 3/8	14.4	13	20 1/4	2 1/4	3 1/4	3/4	2 1/4	2 1/4	1 1/2	2	5	6 1/4	1 5/8	1	1 11/16	1 7/16	9 1/4	1 5/8	22	16	6	2 3/8	2 3/4	2 1/4	2 1/2	13 1/4	1 1/8	1 1/2	3 5/8	7	17 1/2	13/32

SCREW STEERING GEARS.

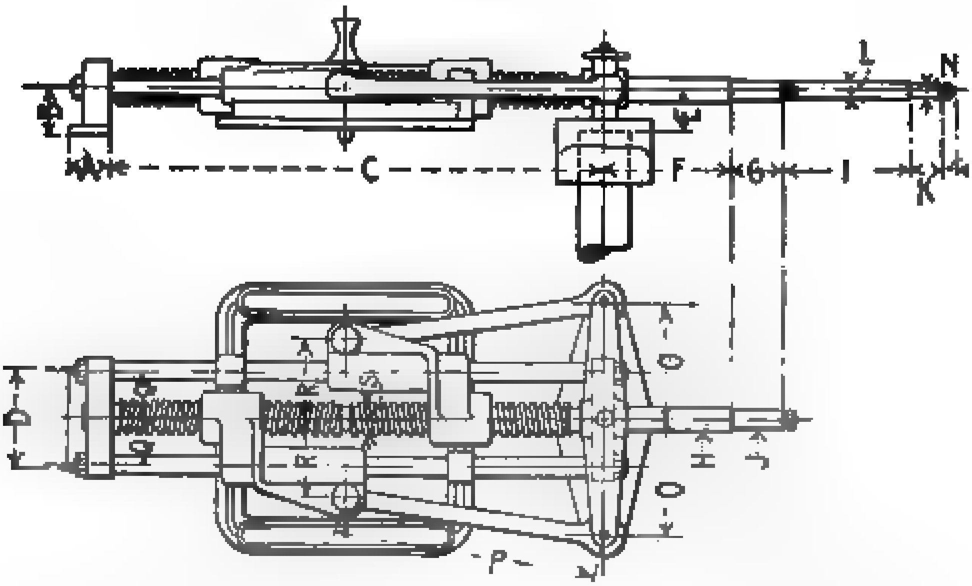


FIG. 300.

Approx. Dia. of Rudder Post	Size of Gear (Screw) Suitable.	Usual Number and Dia. of Steering Wheels.	A	B	C	D	E	F	G	H	I
″	″	′ ″	″	″	′ ″	′ ″	″	′ ″	″	″	′ ″
3	2	One 3–6	3¼	3½	2–3½	7½	2⅜	6¼	4	1½	...
3¼	2¼	One 3–6	3¼	3⅝	2–7¼	7½	2¾	8¼	4	1⅝	...
3½	2½	One 4–0	3½	3¾	2–11	8	3⅛	8⅞	4½	1¾	...
3¾	2¾	One 4–0	3½	4⅛	3–1½	8	3¼	9⅝	4½	2	..
4¼	3	One 4–6	4	4⅛	3–4⅝	8	3⅝	11 7/16	4½	2¼	...
4¾	3¼	One 4–6	4	4½	3–9⅞	8½	4	11⅞	5	2¼	...
5¼	3½	One 5–0	4½	5⅛	4–0½	11	4¼	11¾	5	2½	..
5¾	3¾	One 5–0	4½	5¼	4–4⅝	11	4⅜	12⅞	5	2¾	..
6	4	One 5–6	5	5⅜	4–7⅞	12	4¾	1–2¼	5	3	...
6¼	4¼	One 5–6	5	6	4–10¾	12½	4 15/16	1–2¾	5½	3¼	..
6½	4½	One 6–0	5¼	6½	5–3	1–1	5¼	1–4⅛	5½	3½	..
6¾	4¾	One 6–0	5½	6¾	5–5	1–2	5½	1–5	5½	3¾	.
7	5	One 6–6	6	7	5–6¼	1–3	5⅞	1–5¼	5½	4	.
7½	5¼	One 6–6	6	7¼	5–7⅞	1–3½	6¼	1–5⅝	6	4¼	.
7¾	5½	Two 6–0	6¼	7½	5–10 7/16	1–8½	6½	1–7¼	6	4½	2–0
8½	6	Two 6–6	6⅜	7¾	6–5⅛	1 10	6⅞	1 8⅝	6	5	2–0
9¼	6½	Two 6–6	6½	7¾	6–8¾	2–0	7⅜	1–8⅝	6	5½	2–0
10	7	Two 7–0	6½	8	7 4¾	2–0	8	1–9¾	6	6	2–0
11	7½	Two 7–0	8	8½	8–4½	2–2	8⅞	1 11¼	6	6½	2–0

SCREW STEERING GEARS. — *(Continued.)*

Approx. Dia. of Rudder Post.	Size of Gear (Screw) Suitable.	Usual Number and Dia. of Steering Wheels.	*J*	*K*	*L*	*M*	*N*	*O*	*P*	*Q*	*R*	*S*
"	"	' "	"	"	"	"	"	' "	' "	"	' "	"
3	2	One 3-6	1 1/8			5/8	...	6 3/8	1-2 3/8	2 5/8	4 5/8	2
3 1/4	2 1/4	One 3-6	1 1/2	.	.	3/4	.	7 3/8	1-4 5/8	3	5 1/8	2 1/4
3 3/8	2 1/2	One 4-0	1 1/4	..	.	3/4	.	8 1/4	1 6 1/2	3 1/2	5 3/4	2 1/2
3 1/2	2 3/4	One 4-0	1 3/4	.	.	7/8	...	8 7/8	1-7 3/4	3 5/8	6 1/4	2 3/4
4 1/4	3	One 4-6	2	..	.	1 1/8	...	10	1-9 7/8	4	6 3/4	3
4 3/4	3 1/4	One 4-6	2	.		1 1/8	..	10 3/4	2-0 7/8	4 3/8	7 1/4	[illegible]
5 1/4	3 1/2	One 5-0	2 1/4	.		1 1/4	..	11 1/2	2-2	4 5/8	8	3 1/2
5 3/4	3 3/4	One 5-0	2 1/2	.		1 1/2	.	12 1/4	2-3 7/8	5	8 5/8	3 3/4
6	4	One 5-6	2 3/4			1 1/2		1-1 1/4	2-5 5/8	5 1/4	9 1/4	4
6 1/4	4 1/4	One 5-6	3	..		1 1/2	.	1 1 7/8	2 6 7/8	5 1/2	9 3/4	4 1/4
6 1/2	4 1/2	One 6-0	3 1/4			1 1/2	...	1-2 3/4	2-9 5/8	5 7/8	10 1/4	4 1/2
6 3/4	4 3/4	One 6-0	3 1/2	..		1 1/2	.	1-3 1/4	2-10 1/2	6 1/4	10 3/4	4 3/4
7	5	One 6-6	3 1/2	.		1 1/2	.	1 3 1/2	2 11	6 1/4	10 1/2	5
7 1/2	5 1/4	One 6-6	4	..		1 1/2	.	1-3 3/4	3-0	6 3/4	11 1/2	5 1/4
7 3/4	5 1/2	Two 6-0	4	6	3 1/2	1 1/2	3	1-4 3/8	3-1 1/2	7	11 1/2	5 1/2
8 1/2	6	Two 6-6	4 1/2	6	4	1 1/2	3 1/2	1 6	3-4 5/8	7 5/8	12 3/4	6
9 1/4	6 1/2	Two 6-6	4 1/2	6	4	1 1/2	3 1/2	1 6 3/8	3-6 5/8	7 7/8	1-1	6 1/2
10	7	Two 7 0	4 1/2	6	4	1 1/2	3 1/2	1 8 1/2	3-11 1/8	8 3/4	1 2 3/4	7
11	7 1/2	Two 7-0	5 1/2	6	4 1/2	1 1/2	4	1-10	4-5 1/8	9 3/4	1-4	7 1/2

DECK SEATS.

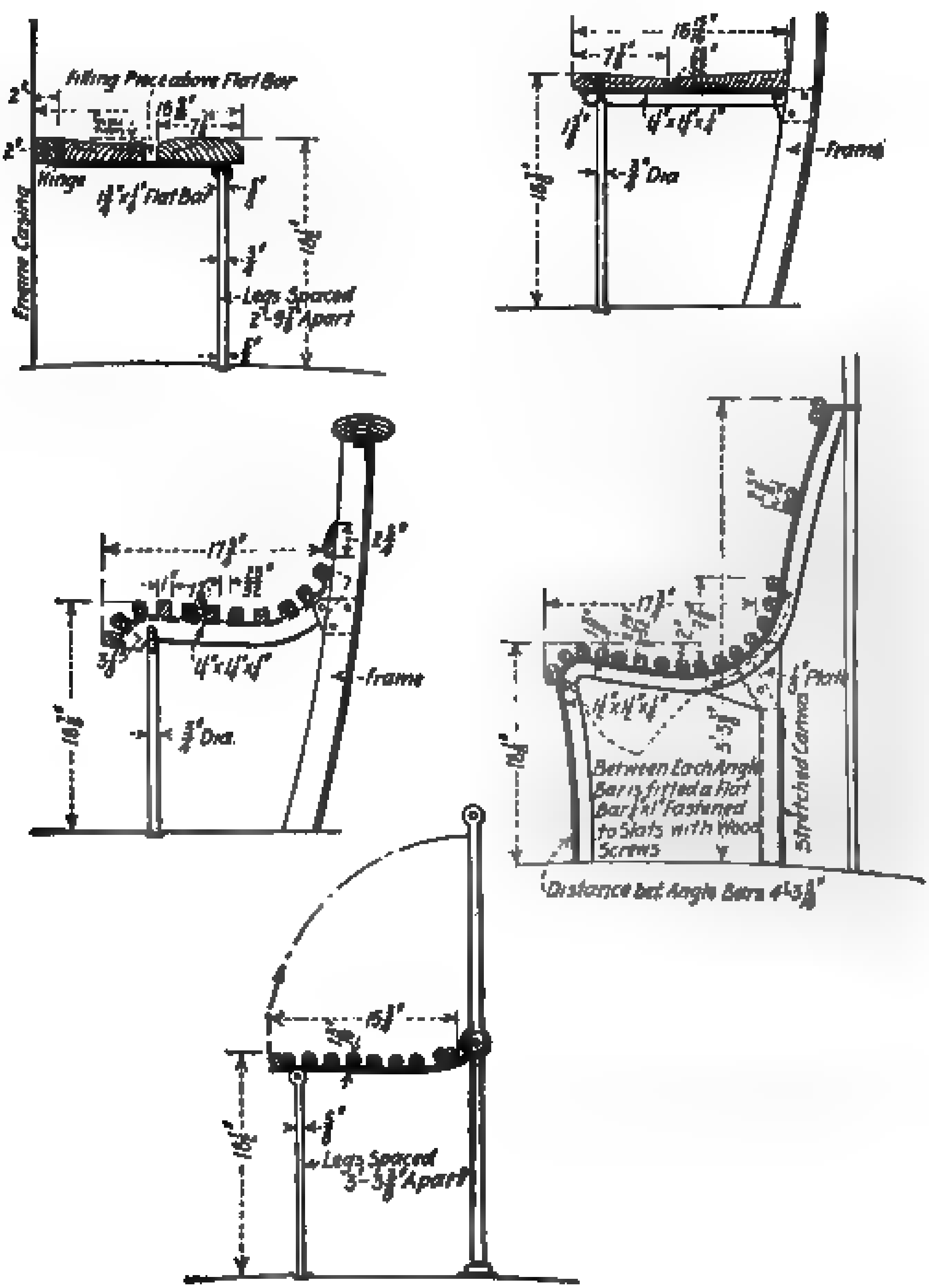


FIG. 301.

DECK SEATS.

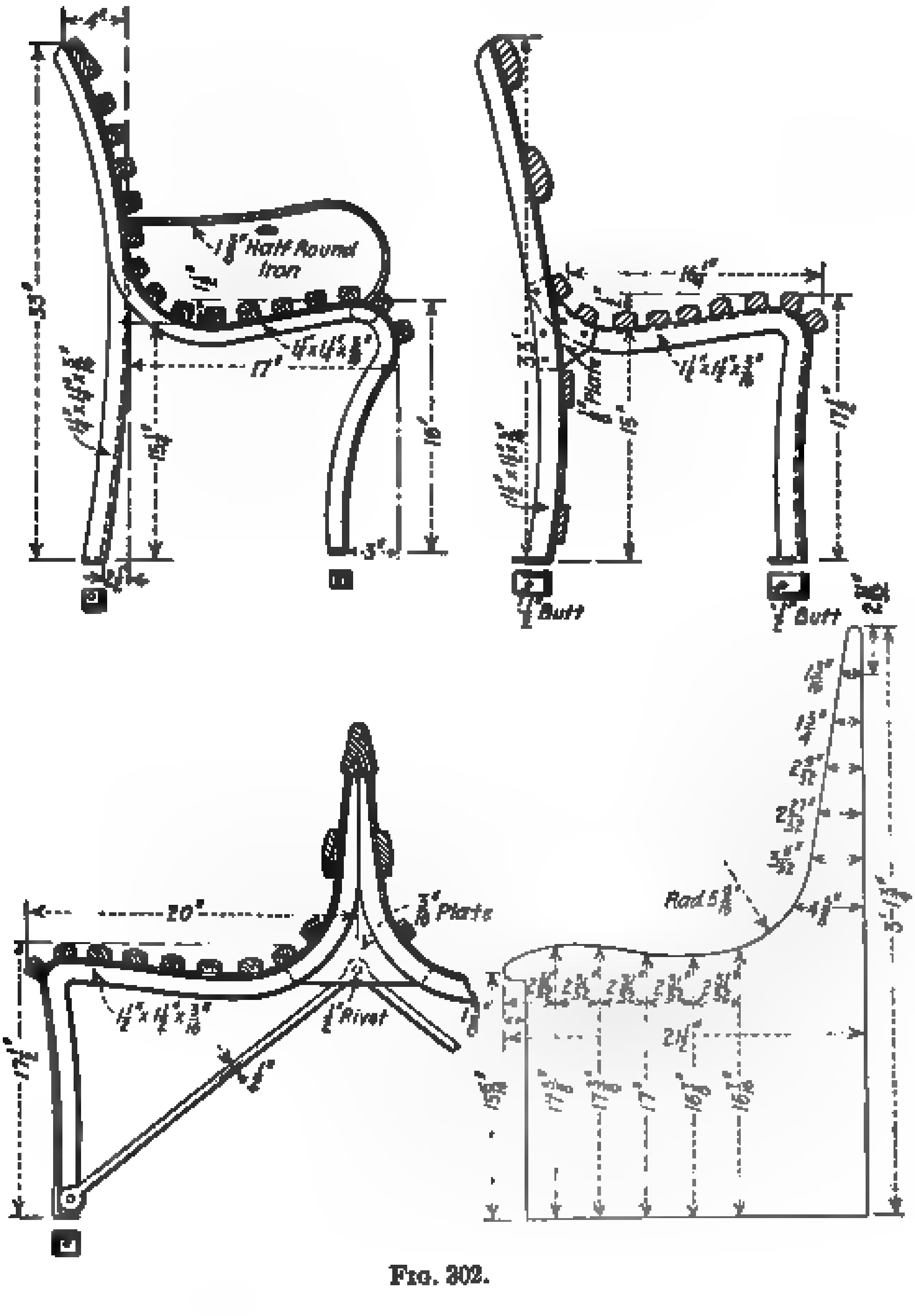


Fig. 302.

DECK SEATS.

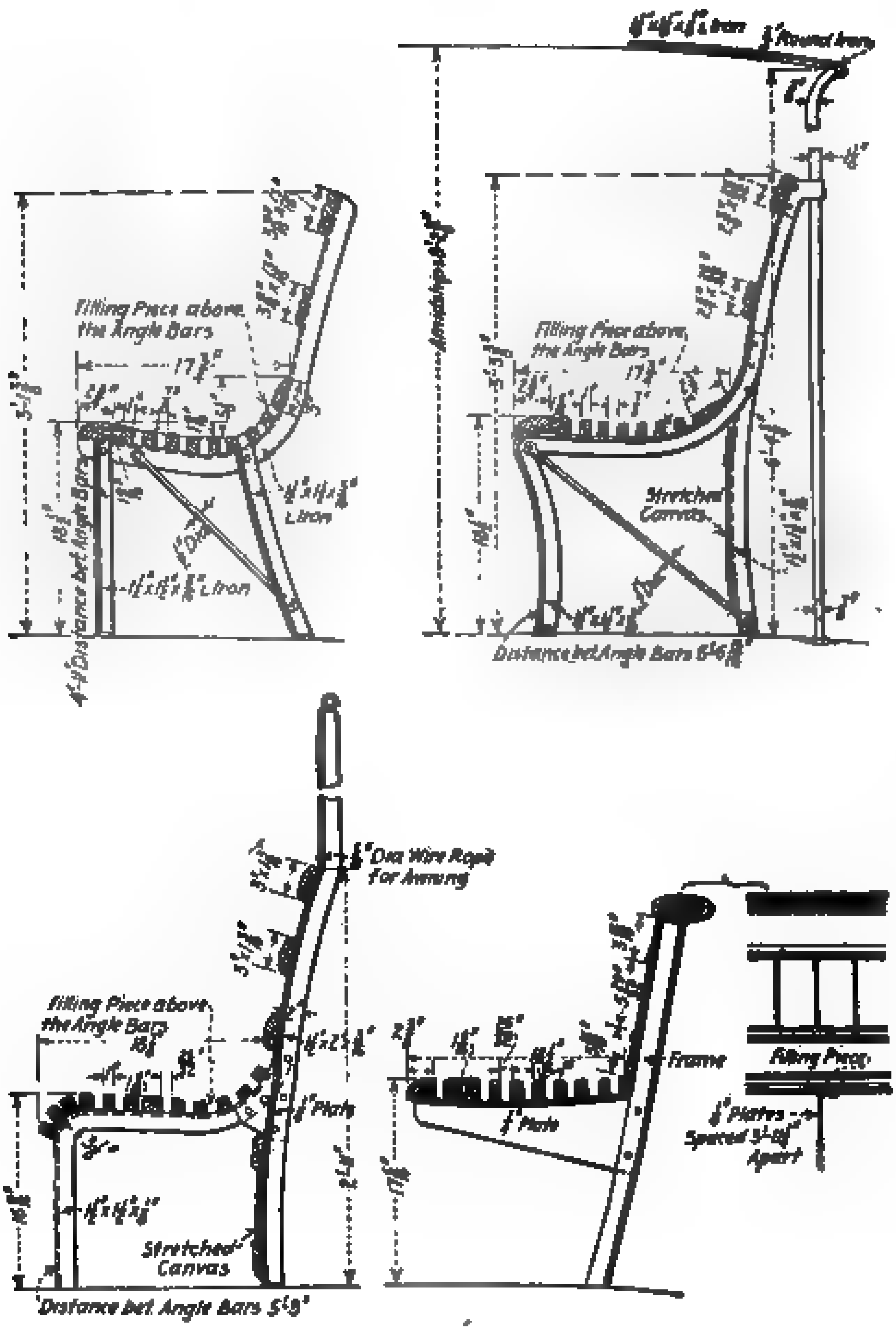


FIG. 303.

WEIGHTS OF BRASS FRAMED SIDELIGHTS.

Diameter (Clear Glass).	Description.	Brass.	Glass.	Total.
In.		Lbs.	Lbs.	Lbs.
9	To open. No deadlight	26	5	31
10	" " " "	28.8	6.2	35
12	" " " "	39.4	8.6	48
15	" " " "	62.25	15.75	78
9	" " With deadlight	50	5	55
10	" " " "	58.5	7.5	66
8	Fixed. No deadlight	6.3	2.7	9
9	" " "	7.1	3.4	10.5
10	" " "	9	4	13
12	" " "	13.3	7.2	20.5

PROPORTIONS OF CHAIN SLIPS.

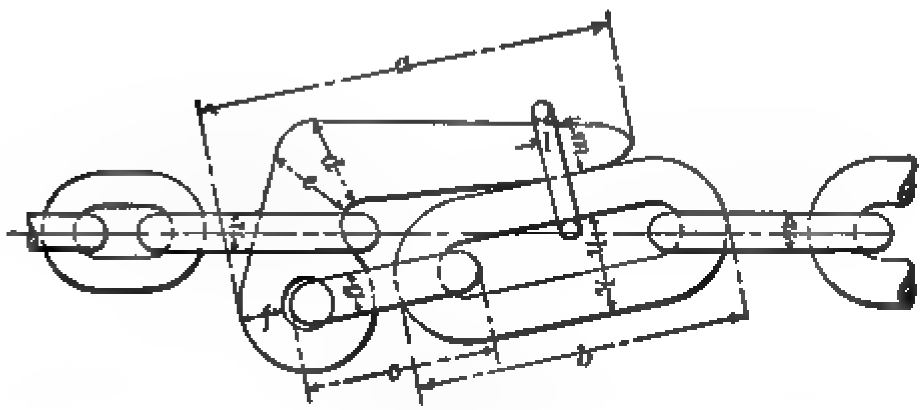


FIG. 304.

SUITABLE FOR Chain	Steel W. R.	a.	b.	c.	d.	e.	f.	g.	h.	k.	l.	m.	n.
		"	"	"	"	"	"	"	"	"	"	"	"
$\frac{7}{16}$" or	$1\frac{1}{2}$"	$4\frac{7}{8}$	$3\frac{15}{16}$	$2\frac{1}{4}$	$\frac{15}{16}$	$\frac{15}{16}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{11}{16}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{5}{8}$	$\frac{7}{16}$
$\frac{9}{16}$" "	2"	$5\frac{11}{16}$	$4\frac{9}{16}$	$2\frac{5}{8}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$\frac{9}{16}$	$\frac{9}{16}$	$\frac{3}{4}$	$\frac{9}{16}$	$\frac{1}{4}$	$\frac{3}{4}$	$\frac{9}{16}$
$\frac{5}{8}$" "	$2\frac{1}{2}$"	$6\frac{1}{2}$	$5\frac{1}{4}$	3	$1\frac{1}{4}$	$1\frac{1}{4}$	$\frac{11}{16}$	$\frac{11}{16}$	$\frac{7}{8}$	$\frac{11}{16}$	$\frac{5}{16}$	$\frac{7}{8}$	$\frac{5}{8}$
$\frac{3}{4}$" "	3"	$8\frac{1}{8}$	$6\frac{1}{2}$	$3\frac{1}{4}$	$1\frac{9}{16}$	$1\frac{9}{16}$	$\frac{13}{16}$	$\frac{3}{4}$	$1\frac{1}{8}$	$\frac{13}{16}$	$\frac{3}{8}$	1	$\frac{3}{4}$
$\frac{7}{8}$" "	$3\frac{1}{2}$"	$8\frac{15}{16}$	$7\frac{9}{16}$	$4\frac{1}{8}$	$1\frac{3}{4}$	$1\frac{3}{4}$	$\frac{15}{16}$	$\frac{15}{16}$	$1\frac{1}{4}$	$\frac{15}{16}$	$\frac{7}{16}$	$1\frac{1}{8}$	$\frac{7}{8}$
1" "	$3\frac{3}{4}$"	$10\frac{9}{16}$	$8\frac{1}{2}$	$4\frac{7}{8}$	2	2	$1\frac{1}{16}$	1	$1\frac{7}{16}$	$1\frac{1}{16}$	$\frac{1}{2}$	$1\frac{1}{4}$	1
$1\frac{1}{16}$" "	4"	$11\frac{3}{8}$	$9\frac{1}{8}$	$5\frac{1}{4}$	$2\frac{5}{16}$	$2\frac{5}{16}$	$1\frac{1}{8}$	$1\frac{1}{16}$	$1\frac{9}{16}$	$1\frac{1}{8}$	$\frac{9}{16}$	$1\frac{3}{8}$	$1\frac{1}{16}$
$1\frac{3}{16}$" "	$4\frac{1}{2}$"	13	$10\frac{1}{2}$	6	$2\frac{1}{2}$	$2\frac{1}{2}$	$1\frac{5}{16}$	$1\frac{1}{4}$	$1\frac{3}{4}$	$1\frac{5}{16}$	$\frac{5}{8}$	$1\frac{5}{8}$	$1\frac{3}{16}$
$1\frac{5}{16}$" "	5"	$14\frac{5}{8}$	$11\frac{3}{4}$	$6\frac{3}{4}$	$2\frac{13}{16}$	$2\frac{13}{16}$	$1\frac{1}{2}$	$1\frac{3}{8}$	2	$1\frac{1}{2}$	$\frac{11}{16}$	$1\frac{3}{4}$	$1\frac{5}{16}$

BOOM MOUNTINGS.

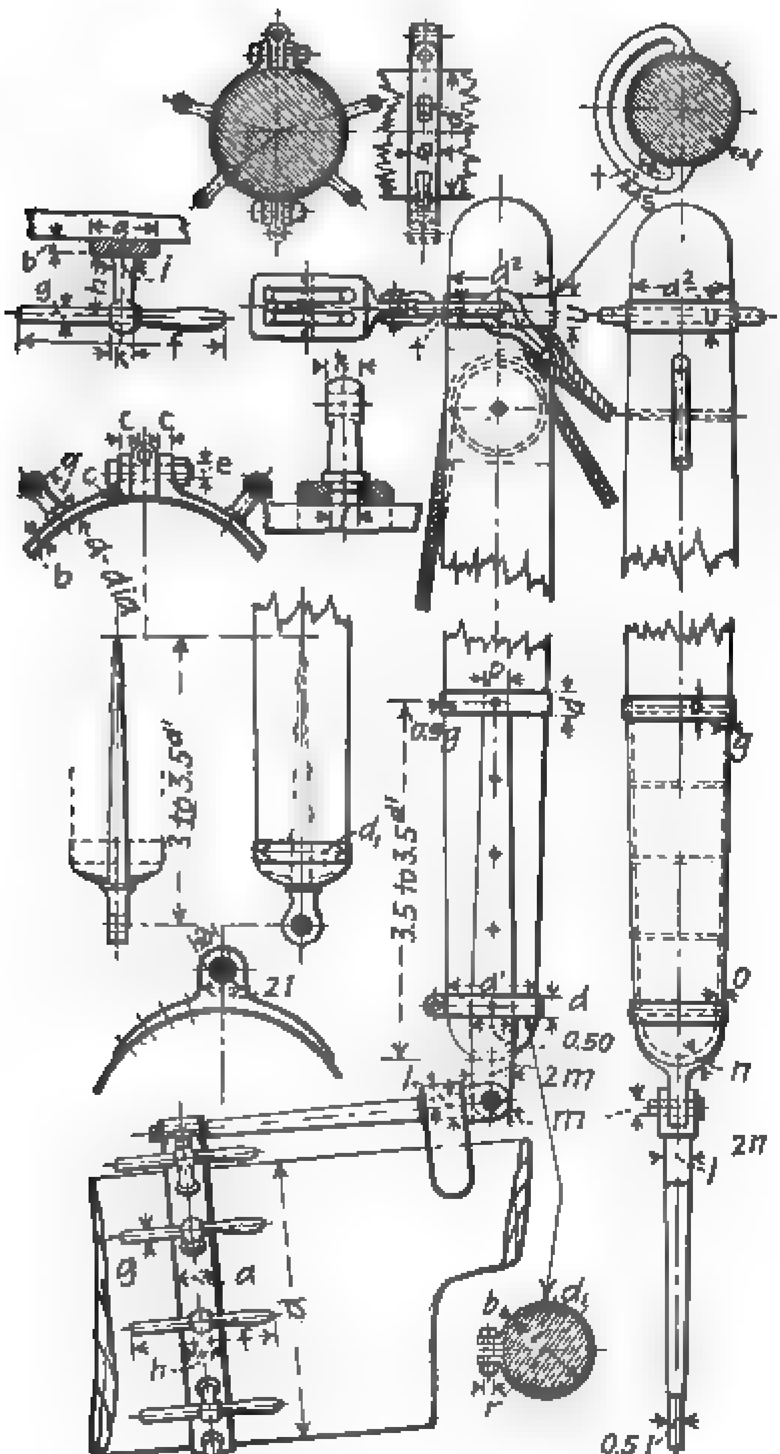


FIG. 305.

BOOM MOUNTINGS.

Diameter of Boom, d	Shoe.				Bands.			
	l	m	n	o	p	q	r	
							Bolt.	Thread.
In.	In.	In.	In.	In.	In.	In.	In.	In.
$3\frac{15}{16}$ to $4\frac{5}{16}$	$1\frac{1}{8}$	$\frac{13}{16}$	$\frac{13}{16}$	$\frac{5}{16}$	$1\frac{7}{8}$	$\frac{5}{16}$	$\frac{5}{8}$	$\frac{5}{8}$
$4\frac{5}{16}$ to $4\frac{3}{4}$	$1\frac{3}{16}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{3}{8}$	$1\frac{15}{16}$	$\frac{1}{4}$	$\frac{11}{16}$	$\frac{5}{8}$
$4\frac{3}{4}$ to $5\frac{1}{8}$	$1\frac{5}{16}$	$\frac{15}{16}$	$\frac{15}{16}$	$\frac{3}{8}$	2	$\frac{5}{16}$	$\frac{11}{16}$	$\frac{5}{8}$
$5\frac{1}{8}$ to $5\frac{1}{2}$	$1\frac{7}{16}$	1	1	$\frac{7}{16}$	$2\frac{1}{8}$	$\frac{5}{16}$	$\frac{11}{16}$	$\frac{3}{4}$
$5\frac{1}{2}$ to $5\frac{7}{8}$	$1\frac{9}{16}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$\frac{1}{2}$	$2\frac{1}{4}$	$\frac{3}{8}$	$\frac{11}{16}$	$\frac{3}{4}$
$5\frac{7}{8}$ to $6\frac{1}{4}$	$1\frac{5}{8}$	$1\frac{3}{16}$	$1\frac{1}{4}$	$\frac{1}{2}$	$2\frac{3}{8}$	$\frac{3}{8}$	$\frac{3}{4}$	$\frac{3}{4}$
$6\frac{1}{4}$ to $6\frac{11}{16}$	$1\frac{3}{4}$	$1\frac{1}{4}$	$1\frac{5}{16}$	$\frac{9}{16}$	$2\frac{7}{16}$	$\frac{7}{16}$	$\frac{13}{16}$	$\frac{7}{8}$
$6\frac{11}{16}$ to $7\frac{1}{8}$	$1\frac{7}{8}$	$1\frac{3}{8}$	$1\frac{3}{8}$	$\frac{5}{8}$	$2\frac{1}{2}$	$\frac{1}{2}$	$\frac{13}{16}$	$\frac{7}{8}$
$7\frac{1}{8}$ to $7\frac{1}{2}$	2	$1\frac{7}{16}$	$1\frac{1}{2}$	$\frac{5}{8}$	$2\frac{5}{8}$	$\frac{1}{2}$	1	$\frac{7}{8}$
$7\frac{1}{2}$ to $7\frac{7}{8}$	$2\frac{1}{16}$	$1\frac{1}{2}$	$1\frac{9}{16}$	$\frac{11}{16}$	$2\frac{11}{16}$	$\frac{9}{16}$	1	1
$7\frac{7}{8}$ to $8\frac{1}{4}$	$2\frac{1}{8}$	$1\frac{9}{16}$	$1\frac{5}{8}$	$\frac{11}{16}$	$2\frac{3}{4}$	$\frac{5}{8}$	$1\frac{1}{16}$	1
$8\frac{1}{4}$ to $8\frac{5}{8}$	$2\frac{3}{16}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$\frac{3}{4}$	$2\frac{13}{16}$	$\frac{5}{8}$	$1\frac{1}{8}$	1
$8\frac{5}{8}$ to 9	$2\frac{5}{16}$	$1\frac{3}{4}$	$1\frac{13}{16}$	$\frac{13}{16}$	$2\frac{15}{16}$	$\frac{11}{16}$	$1\frac{1}{8}$	$1\frac{1}{8}$
9 to $9\frac{7}{16}$	$2\frac{3}{8}$	$1\frac{13}{16}$	$1\frac{7}{8}$	$\frac{13}{16}$	3	$\frac{11}{16}$	$1\frac{3}{16}$	$1\frac{1}{8}$
$9\frac{7}{16}$ to $9\frac{7}{8}$	$2\frac{7}{16}$	$1\frac{7}{8}$	2	$\frac{7}{8}$	$3\frac{1}{16}$	$\frac{3}{4}$	$1\frac{1}{4}$	$1\frac{1}{8}$

(From Middendorf's "Bemastung und Takelung der Schiffe," by permission of the Publishers.)

BOOM MOUNTINGS.

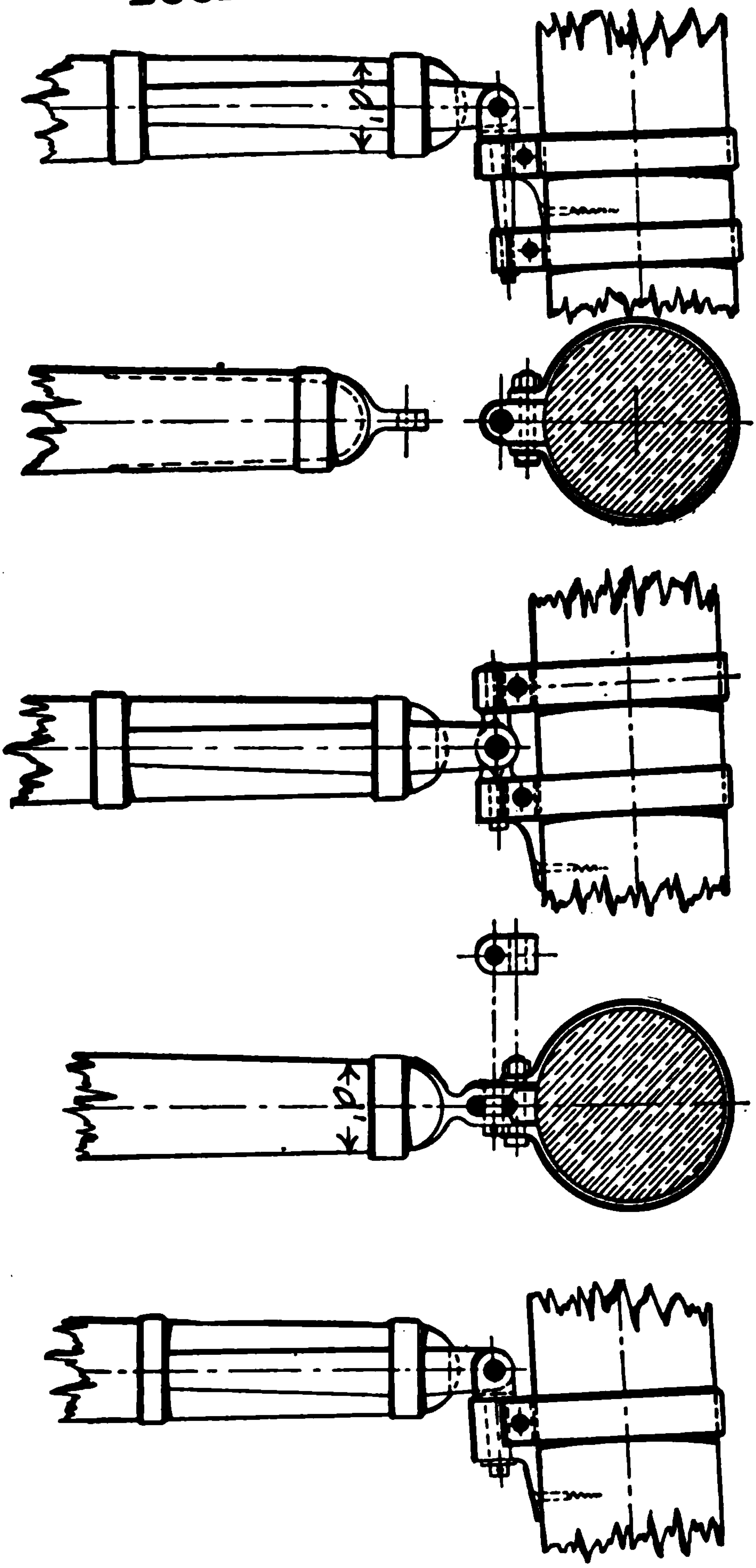


FIG. 306.

SPIDER BANDS.

Diameter of Mast, d	Bands.					Belay Pins.					
	a	b	c	e		f	g	h	i	k	No. of Pins.
				Bolt.	Thread.						
In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	
7 3/8 to 8 11/16	2 3/4	1/2	11/16	15/16	7/8	8 1/2	5/8	2 1/4	13/16	7/8	4
8 11/16 to 9 7/16	2 13/16	9/16	11/16	1	7/8	8 1/2	5/8	2 1/4	13/16	7/8	4
9 7/16 to 10 1/4	2 13/16	9/16	11/16	1	1	[illegible] 3/4	5/8	2 1/2	13/16	15/16	4
10 1/4 to 11	2 7/8	9/16	3/4	1	1	9	5/8	2 5/8	13/16	15/16	4
11 to 11 13/16	2 7/8	9/16	3/4	1 1/16	1	9	5/8	2 5/8	7/8	15/16	4
11 13/16 to 12 5/8	2 15/16	5/8	3/4	1 1/16	1	9 1/4	3/4	2 3/4	7/8	1	4
12 5/8 to 13 3/8	3	5/8	13/16	1 1/16	1	9 1/2	3/4	2 7/8	7/8	1	6
13 3/8 to 14 3/16	3	5/8	13/16	1 1/16	1	9 3/4	3/4	3	15/16	1 1/16	6
14 3/16 to 14 15/16	3 1/16	5/8	13/16	1 1/8	1	9 3/4	3/4	3 1/8	15/16	1 1/16	6
14 15/16 to 15 3/4	3 1/8	5/8	13/16	1 1/8	1 1/8	10	3/4	3 1/8	15/16	1 1/16	6
15 3/4 to 16 1/2	3 1/8	11/16	7/8	1 1/8	1 1/8	10 1/4	3/4	3 1/4	1	1 1/16	6
16 1/2 to 17 5/16	3 3/16	11/16	7/8	1 1/8	1 1/8	10 1/2	3/4	3 3/8	1	1 1/8	6
17 5/16 to 18 1/8	3 1/4	11/16	7/8	1 3/16	1 1/8	10 1/2	3/4	3 3/8	1	1 1/8	8
18 1/8 to 18 7/8	3 1/4	11/16	7/8	1 3/16	1 1/8	10 3/4	3/4	3 1/2	1 1/16	1 1/8	8
18 7/8 to 19 11/16	3 5/16	11/16	15/16	1 3/16	1 1/8	11	7/8	3 1/2	1 1/16	1 1/8	8
19 11/16 to 20 1/2	3 3/8	3/4	15/16	1 3/16	1 1/8	11 1/4	7/8	3 5/8	1 1/16	1 3/16	[illegible]
20 1/2 to 21 1/4	3 3/8	3/4	15/16	1 1/4	1 1/8	11 1/2	7/8	3 3/4	1 1/16	1 3/16	[illegible]
21 1/4 to 22 1/16	3 7/16	3/4	15/16	1 1/4	1 1/8	11 1/2	7/8	3 7/8	1 1/8	1 1/4	8
22 1/16 to 22 13/16	3 7/16	3/4	1	1 1/4	1 1/4	11 3/4	7/8	3 7/8	1 1/8	1 1/4	10
22 13/16 to 23 5/8	3 1/2	3/4	1	1 1/4	1 1/4	12	1	4	1 1/8	1 1/4	10
23 5/8 to 24 7/16	3 9/16	13/16	1	1 5/16	1 1/4	12 1/4	1	4 1/8	1 3/16	1 1/4	10
24 7/16 to 25 3/16	3 9/16	13/16	1 1/16	1 5/16	1 1/4	12 1/4	1	4 1/4	1 3/16	1 5/16	10
25 3/16 to 26	3 5/8	13/16	1 1/16	1 5/16	1 1/4	12 1/2	1	4 3/8	1 3/16	1 5/16	10
26 to 26 13/16	3 5/8	13/16	1 1/16	1 5/16	1 1/4	12 3/4	1	4 3/8	1 1/4	1 3/8	10
26 13/16 to 27 9/16	3 11/16	7/8	1 1/8	1 3/8	1 1/4	13	1	4 1/2	1 1/4	1 3/8	12
27 9/16 to 28 3/8	3 3/4	7/8	1 1/8	1 3/8	1 1/4	13 1/4	1 1/16	4 5/8	1 1/4	1 3/8	12
28 3/8 to 29 1/8	3 3/4	7/8	1 1/8	1 3/8	1 1/4	13 1/2	1 1/16	4 5/8	1 1/4	1 3/8	12

Approx. Rule

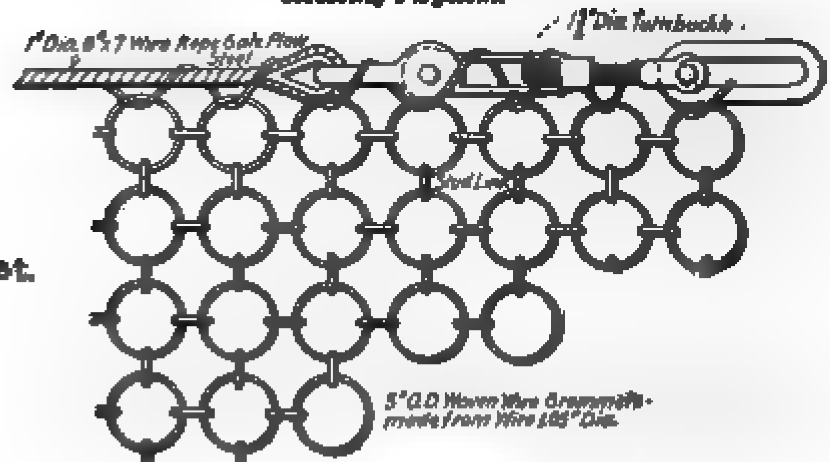
Breadth "a" = $.8\sqrt{\text{diam. of spar}}$

Thickness "b" = $.17\sqrt{\text{diam. of spar}}$

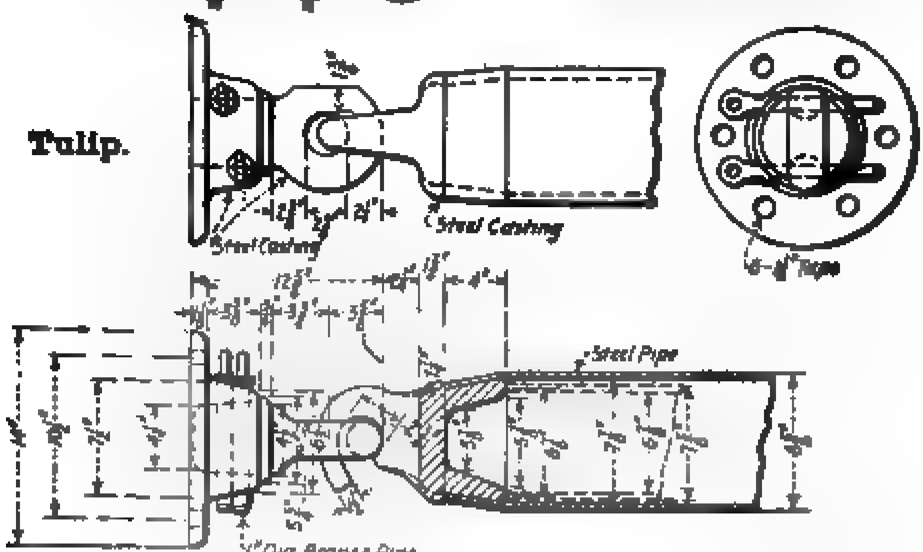
TORPEDO NET DETAILS.

Roebling's System.

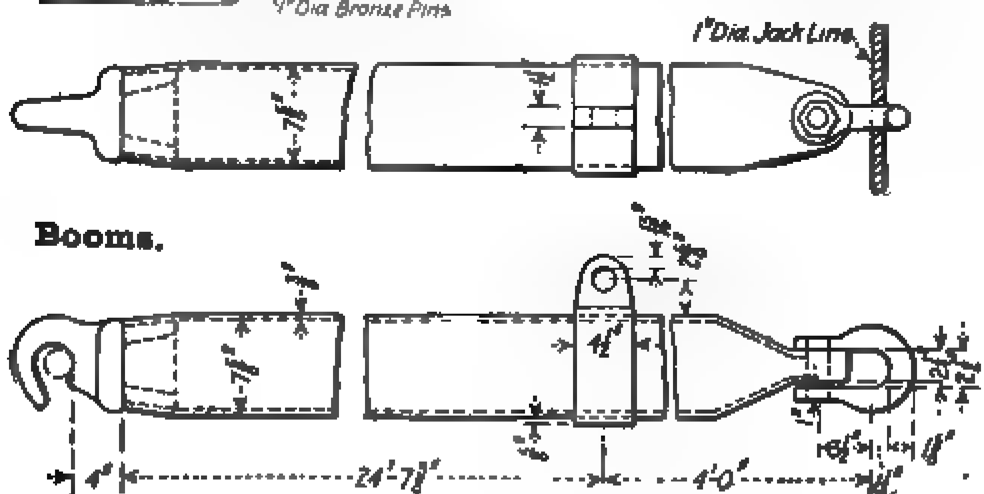
Net.



Tulip.



Booms.



Figs. 307-309.

GAFF MOUNTINGS.

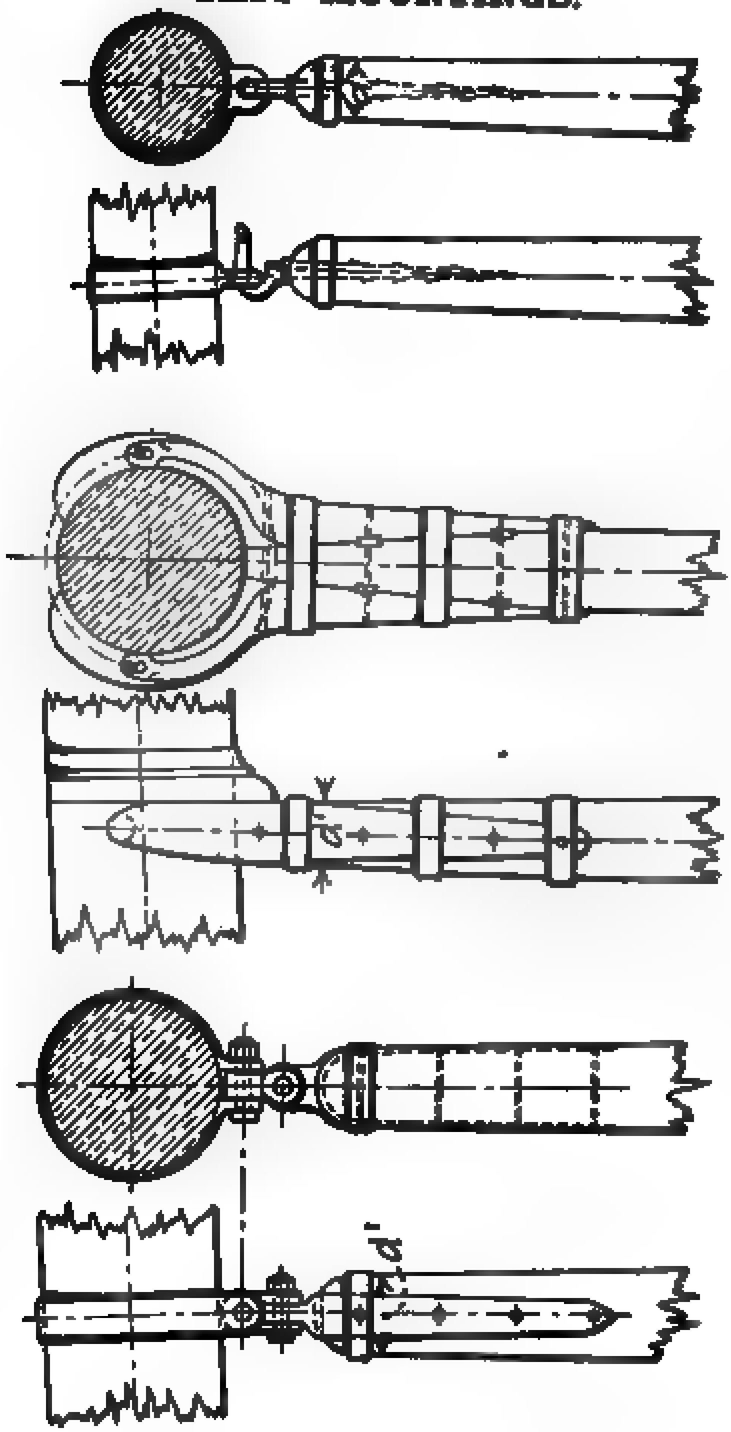


Fig. 310.

MOUNTINGS FOR GAFFS.

Greatest Diam of Gaff, d	Shoe and Slide. a	b	c	e	e_1	f	g	h	i	k	l	Bands. m	n	o Bolt.	o Th'd.	p	q	r	Throat Shackle. s	t	u	v	w
In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
3 1/16 to 3 13/16	5/16	1 3/16	1 9/16			5/16									.				1/4	3/8	1/4	3/8	3/8
3 13/16 to 4 3/16	3/8	1 5/16	1 11/16			3/8									.		.	.	5/16	3/8	5/16	3/8	7/16
4 3/16 to 4 3/4	1/2	1 7/16	1 13/16			3/8												..	5/16	3/8	3/8	3/8	7/16
4 3/4 to 5 1/8	11/16	1 9/16	1 15/16	4 3/4	6 11/16	3/8	1 1/4	2 9/16	1/2	13/16	1	1 5/16	1/2	5/8	1/2	3/8	1 1/2	5/16	5/16	7/16	3/8	9/16	1/2
5 1/8 to 5 1/2	11/16	1 5/8	2 1/16	5 1/8	7 1/8	7/16	1 5/16	2 3/4	1/2	13/16	1 1/8	1 3/8	1/2	5/8	1/2	7/16	1 9/16	5/16	3/8	1/2	7/16	5/8	9/16
5 1/2 to 5 7/8	3/4	1 3/4	2 3/16	5 1/2	7 1/2	7/16	1 3/8	2 15/16	9/16	7/8	1 3/16	1 7/16	9/16	11/16	1/2	7/16	1 11/16	3/8	3/8	1/2	7/16	11/16	9/16
5 7/8 to 6 1/4	13/16	1 13/16	2 5/16	5 7/8	7 3/4	1/2	1 7/16	3 1/8	5/8	15/16	1 1/4	1 1/2	9/16	11/16	1/2	1/2	1 3/4	3/8		1/2			...
6 1/4 to 6 11/16	13/16	1 7/8	2 3/8	6 1/4	8 1/4	1/2	1 9/16	3 3/8	3/4	1	1 3/8	1 5/8	9/16	3/4	5/8	1/2	1 7/8	3/8	.	9/16	..	.	...
6 11/16 to 7 1/8	7/8	2	2 1/2	6 11/16	8 5/8	9/16	1 5/8	3 9/16	3/4	1	1 7/16	1 11/16	5/8	13/16	5/8	1/2	2	7/16		5/8	.	. .	....
7 1/8 to 7 1/2	15/16	2 1/16	2 5/8	7 1/8	9	9/16	1 11/16	3 3/4	13/16	1 1/16	1 1/2	1 3/4	5/8	13/16	5/8	1/2	2 1/16	7/16	.	5/8	...	...	. .
7 1/2 to 7 7/8	15/16	2 1/8	2 3/4	7 1/2	9 7/16	5/8	1 13/16	3 15/16	7/8	1 1/8	1 9/16	2	5/8	7/8	3/4	9/16	2 3/16	7/16	. .	11/16	.	. .	. .
7 7/8 to 8 1/4	1	2 3/16	2 7/8	7 7/8	9 3/4	5/8	1 7/8	4 1/8	1	1 3/16	1 5/8	2 1/16	11/16	15/16	3/4	9/16	2 5/16	1/2	...	11/16	. .	. .	.
8 1/4 to 8 5/8	1	2 5/16	3 1/16	8 1/4	10 1/4	5/8	2	4 5/16	1	1 1/4	1 3/4	2 1/4	11/16	15/16	3/4	5/8	2 3/8	1/2	.	3/4	....	...	..
8 5/8 to 9	1 1/16	2 3/8	3 3/16	8 5/8	10 5/8	11/16	2 1/16	4 1/2	1 1/8	1 1/4	1 13/16	2 5/16	11/16	1	3/4	5/8	2 1/2	1/2		13/16	.	..	..
9 to 9 7/16	1 1/8	2 7/16	3 3/8	9	11	3/4	2 1/4	4 3/4	1 1/8	1 3/8	1 7/8	2 7/16	3/4	1	1	5/8	2 5/8	9/16	...	13/16		..	...
9 7/16 to 9 7/8	1 3/16	2 1/2	3 9/16	9 7/16	11 7/16	3/4	2 1/4	4 15/16	1 3/16	1 7/16	2	2 1/2	3/4	1 1/16	1	11/16	2 11/16	9/16	....	7/8	..	. .	...

GAFF MOUNTINGS.

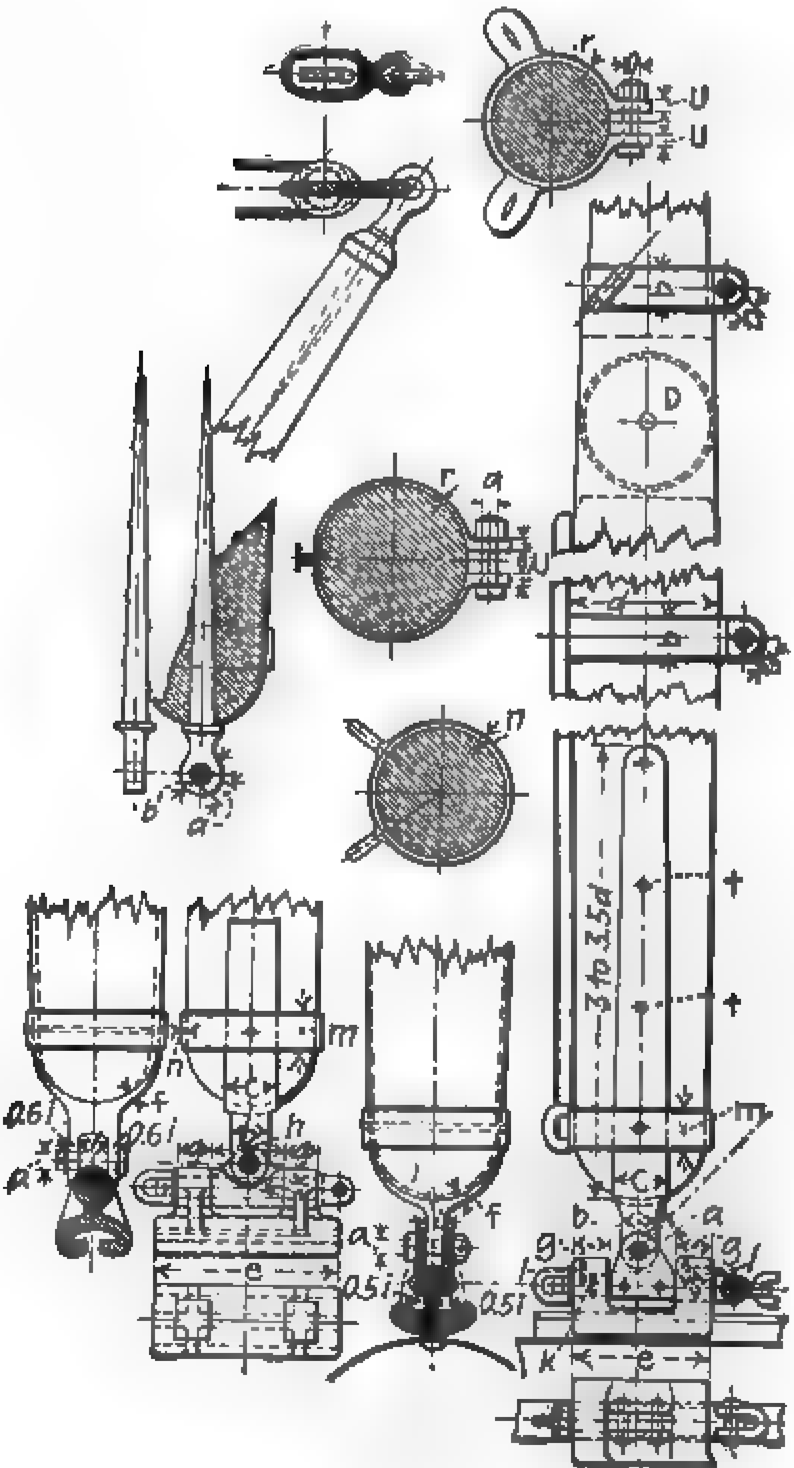


FIG. 311.

GAFF MOUNTINGS.

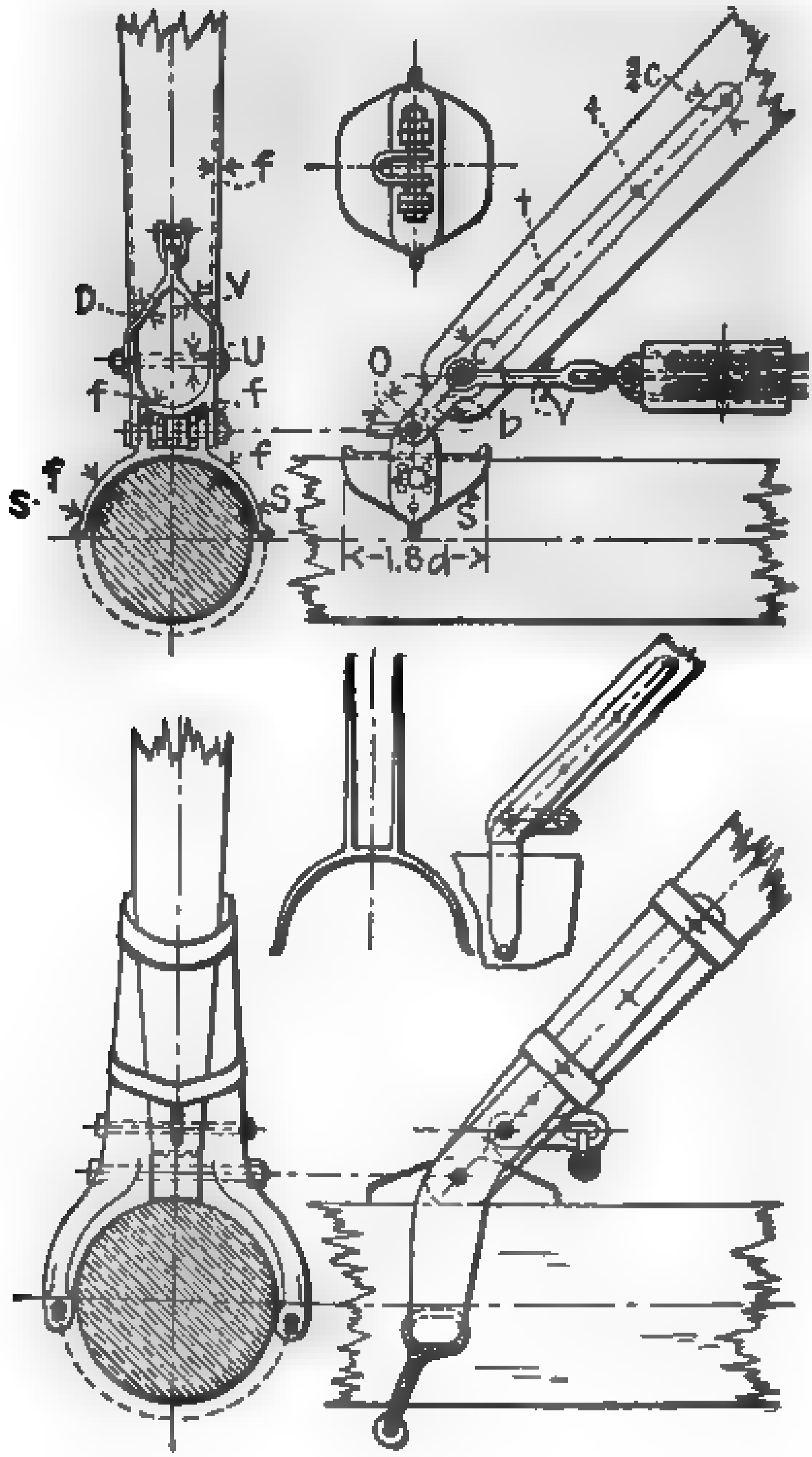
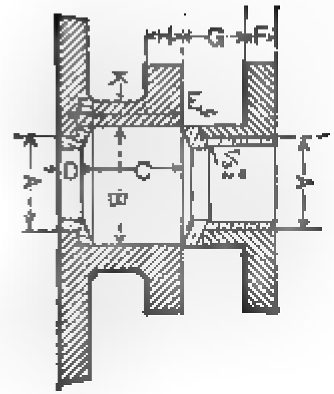


FIG. 312.



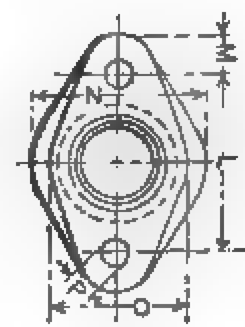
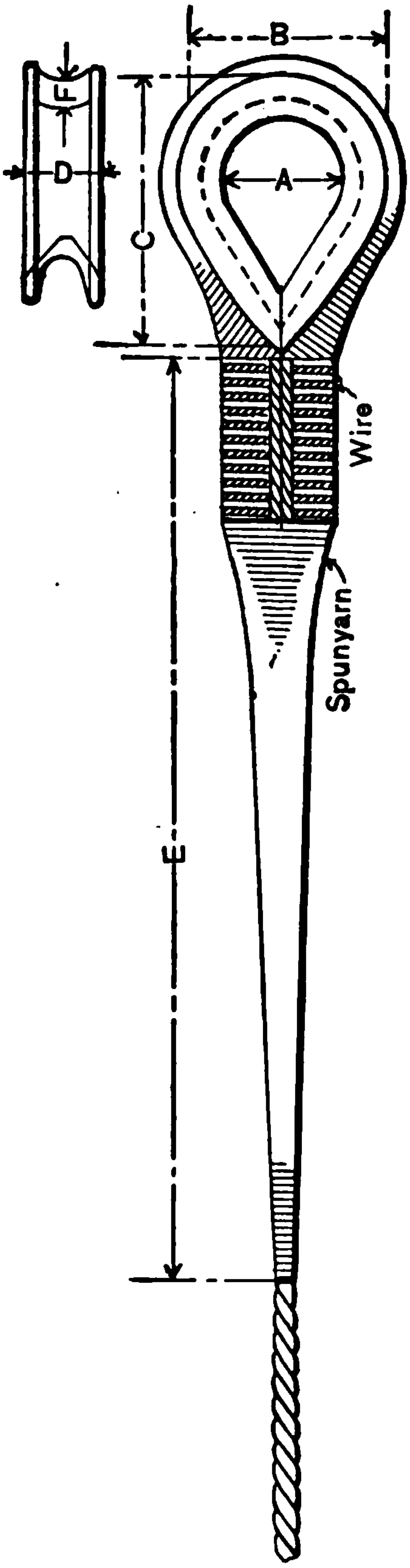


FIG. 313.

STUFFING BOXES AND GLANDS.

Dia. of Rod.	A	B.	C.		D.	E.	F.		G.	H.	K	L.	M.	N.	O.	P.	
			High Press.	Low Press.			Cast Iron.	Brass									
″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	
[illegible]	[illegible]	1	1 [illegible]	1 [illegible]	[illegible]	[illegible]	...	[illegible]	[illegible]	[illegible]	[illegible]	1 [illegible]	[illegible]	1 [illegible]	1 [illegible]	[illegible]	One Pattern for Glands.
[illegible]	[illegible]	1 [illegible]	1 [illegible]	1 [illegible]	[illegible]	[illegible]	...	[illegible]	[illegible]	[illegible]	[illegible]	1 [illegible]	[illegible]	1 [illegible]	1 [illegible]	[illegible]	
[illegible]	[illegible]	1 [illegible]	1 [illegible]	1 [illegible]	[illegible]	[illegible]	...	[illegible]	[illegible]	[illegible]	[illegible]	1 [illegible]	[illegible]	1 [illegible]	1 [illegible]	[illegible]	One Pattern for Glands.
[illegible]	[illegible]	1 [illegible]	1 [illegible]	1 [illegible]	[illegible]	[illegible]	...	[illegible]	[illegible]	[illegible]	[illegible]	1 [illegible]	[illegible]	2	1 [illegible]	[illegible]	
[illegible]	1 [illegible]	1 [illegible]	1 [illegible]	1 [illegible]	[illegible]	[illegible]	...	[illegible]	[illegible]	[illegible]	[illegible]	2 [illegible]	[illegible]	2 [illegible]	1 [illegible]	[illegible]	One Pattern for Glands.
[illegible]	1 [illegible]	1 [illegible]	1 [illegible]	1 [illegible]	[illegible]	[illegible]	...	[illegible]	[illegible]	[illegible]	[illegible]	2 [illegible]	[illegible]	2 [illegible]	1 [illegible]	[illegible]	
[illegible]	1 [illegible]	1 [illegible]	1 [illegible]	1 [illegible]	[illegible]	[illegible]	...	[illegible]	[illegible]	[illegible]	[illegible]	2 [illegible]	[illegible]	2 [illegible]	1 [illegible]	[illegible]	One Pattern for Glands.
[illegible]	1 [illegible]	1 [illegible]	1 [illegible]	1 [illegible]	[illegible]	[illegible]	...	[illegible]	[illegible]	[illegible]	[illegible]	2 [illegible]	[illegible]	2 [illegible]	1 [illegible]	[illegible]	
1	1 [illegible]	1 [illegible]	2 [illegible]	1 [illegible]	[illegible]	[illegible]	...	[illegible]	1 [illegible]	[illegible]	[illegible]	2 [illegible]	[illegible]	2 [illegible]	2	[illegible]	
1 [illegible]	1 [illegible]	1 [illegible]	2 [illegible]	1 [illegible]	[illegible]	[illegible]	...	[illegible]	1 [illegible]	[illegible]	[illegible]	2 [illegible]	[illegible]	2 [illegible]	2 [illegible]	[illegible]	
1 [illegible]	1 [illegible]	2	2 [illegible]	1 [illegible]	[illegible]	[illegible]	...	[illegible]	1 [illegible]	[illegible]	[illegible]	3	[illegible]	3	2 [illegible]	[illegible]	
1 [illegible]	1 [illegible]	2 [illegible]	2 [illegible]	1 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1 [illegible]	[illegible]	[illegible]	3 [illegible]	[illegible]	3 [illegible]	2 [illegible]	[illegible]	
1 [illegible]	1 [illegible]	2 [illegible]	2 [illegible]	1 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1 [illegible]	[illegible]	[illegible]	3 [illegible]	[illegible]	3 [illegible]	2 [illegible]	[illegible]	
1 [illegible]	2	2 [illegible]	2 [illegible]	1 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1 [illegible]	[illegible]	[illegible]	3 [illegible]	[illegible]	3 [illegible]	2 [illegible]	[illegible]	
1 [illegible]	2 [illegible]	2 [illegible]	3	2	[illegible]	[illegible]	[illegible]	[illegible]	1 [illegible]	[illegible]	[illegible]	4 [illegible]	[illegible]	4 [illegible]	3 [illegible]	[illegible]	
1 [illegible]	2 [illegible]	2 [illegible]	3	2	[illegible]	[illegible]	[illegible]	[illegible]	1 [illegible]	[illegible]	[illegible]	4 [illegible]	[illegible]	4 [illegible]	3 [illegible]	[illegible]	
2	2 [illegible]	3	3	2	[illegible]	[illegible]	[illegible]	[illegible]	1 [illegible]	[illegible]	[illegible]	4 [illegible]	[illegible]	4 [illegible]	3 [illegible]	[illegible]	
2 [illegible]	2 [illegible]	3 [illegible]	3	2	[illegible]	[illegible]	[illegible]	[illegible]	1 [illegible]	[illegible]	[illegible]	4 [illegible]	[illegible]	4 [illegible]	3 [illegible]	[illegible]	
2 [illegible]	2 [illegible]	3 [illegible]	3 [illegible]	2 [illegible]	1	[illegible]	[illegible]	[illegible]	1 [illegible]	1	[illegible]	5 [illegible]	1	5	3 [illegible]	[illegible]	
2 [illegible]	2 [illegible]	3 [illegible]	3 [illegible]	2 [illegible]	1	[illegible]	[illegible]	[illegible]	1 [illegible]	1	[illegible]	5 [illegible]	1	5 [illegible]	3 [illegible]	[illegible]	
2 [illegible]	2 [illegible]	3 [illegible]	3 [illegible]	2 [illegible]	1	[illegible]	[illegible]	[illegible]	1 [illegible]	1	[illegible]	5 [illegible]	1	5 [illegible]	4	[illegible]	

THIMBLES FOR WIRE ROPE.



Wire Rope. Circ.	Wire Rope. Dia.	A.	B.	C.	D.	E.	F.
"	"	"	"	"	"	"	"
2	5/8	2 3/8	4	5	1 1/8	15	5/16
2 1/2	13/16	2 1/2	4	5 1/2	1 1/4	19	3/8
3	15/16	3 5/8	6	8 1/2	1 3/4	23	1/2
3 1/2	1 1/8	4	6 1/2	9	1 7/8	27	1/2
4	1 1/4	4	7	9 1/2	2 1/4	31	11/16
4 1/2	1 7/16	4	7	9 1/2	2 1/2	35	7/8
5	1 9/16	5	8 1/2	11 1/2	2 3/4	39	7/8
5 1/2	1 3/4	5	8 1/2	11 1/2	3	43	7/8
6	1 7/8	6	11 1/2	15	3 1/2	46	1 1/4
6 1/2	2 1/16	6	11 1/2	15	3 3/4	49	1 1/4
7	2 3/16	6	11 1/2	15	4	52	1 1/4
7 1/2	2 3/8	7 1/2	15	20	4 3/8	55	1 3/4
8	2 1/2	7 1/2	15	20	4 5/8	58	1 3/4
8 1/2	2 11/16	7 1/2	15	20	4 7/8	60	1 3/4
9	2 13/16	7 1/2	15	20	5 1/8	60	1 3/4

Fig. 314.

TOGGLE PINS (STANDARD).

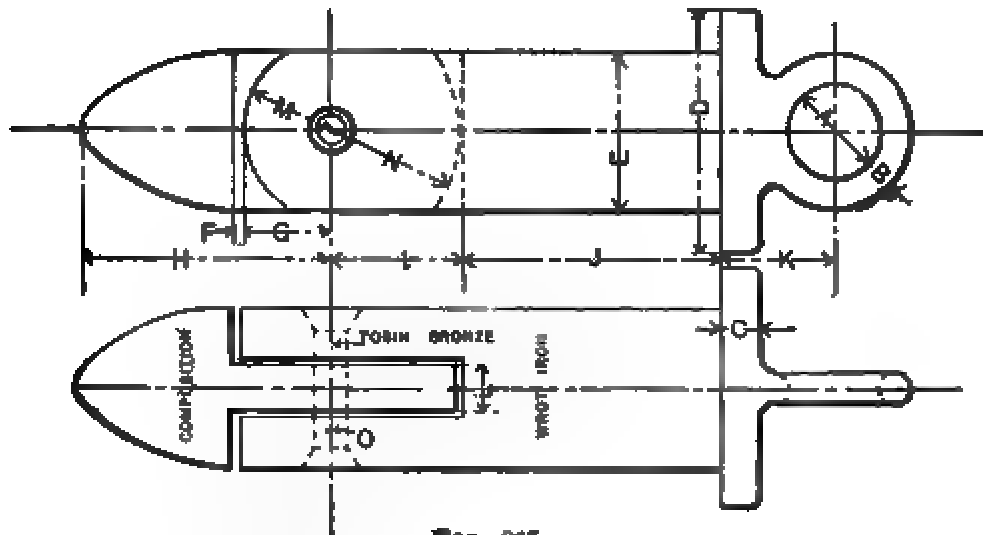


FIG. 315.

Size of Pin.	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.	L.	M.	N.	O.
"	"	"	"	"	"	"	"	"	"		"	"	"	"	"
3/8	1/2	3/16	1/8	5/8	3/8	1/16	1/4	3/4	5/16	To Suit Work.	9/16	1/8	1/4	3/4	1/8
1/2	3/4	1/4	3/16	13/16	1/2	1/16	5/16	1	1/2		3/4	1/4	5/16	7/16	3/16
5/8	3/4	1/4	3/16	1	5/8	1/16	3/8	1 1/4	5/8		3/4	5/16	3/8	9/16	3/16
3/4	3/4	1/4	3/16	1 3/16	3/4	1/16	7/16	1 1/2	11/16		3/4	1/4	7/16	5/8	3/16
7/8	3/4	1/4	1/4	1 3/8	7/8	1/16	1/2	1 3/4	13/16		13/16	1/4	1/2	3/4	1/4
1	3/4	1/4	1/4	1 1/2	1	1/16	9/16	2	7/8		13/16	1/4	9/16	13/16	1/4
1 1/8	3/4	1/4	5/16	1 3/4	1 1/8	1/16	5/8	2	15/16		7/8	3/8	5/8	7/8	1/4
1 1/4	3/4	1/4	5/16	1 7/8	1 1/4	1/16	11/16	2	1 1/16		7/8	3/8	11/16	1	1/4

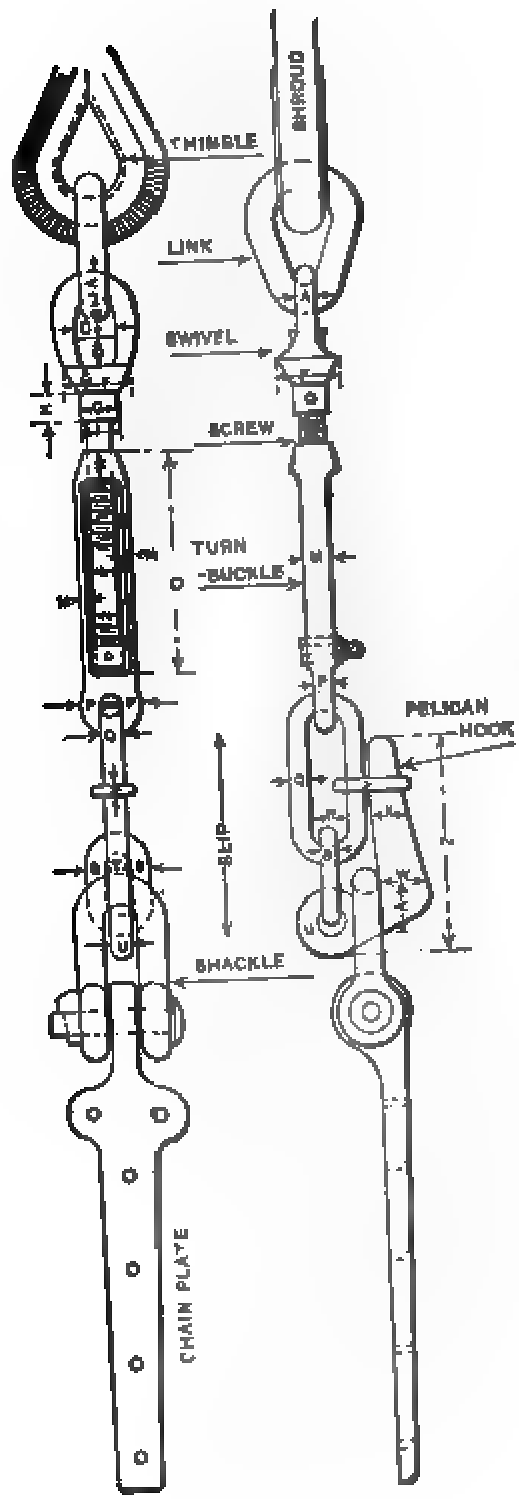

THIMBLE
SHROUD
LINK
SWIVEL
SCREW
TURN
-BUCKLE
PELICAN
-HOOK
SLIP
SHACKLE
CHAIN PLATE

FIG. 316.

ADMIRALTY TURNBUCKLES, ETC.

Steel Wire Rigging.

	7″ & 6 1/2″	6″ & 5 1/2″	5″ & 4 1/2″	4″ & 3 1/2″	3″ & 2 1/2″	2″ & 1 1/2″
A	1 7/8″	1 3/4″	1 1/2″	1 1/4″	1″	3/4″
B	4 1/2″	4 1/4″	3 1/2″	2 1/2″	2″	1 1/2″
C	4″	3 3/4″	3 1/4″	2 1/2″	2″	1 1/2″
D	2 5/8″	2 3/8″	2 1/8″	1 3/4″	1 3/8″	1″
E	2 5/8″	2 3/8″	2 1/8″	1 3/4″	1 3/8″	1″
F	6″	5 1/2″	4 3/4″	3 3/4″	3 1/8″	2 5/8″
G	4″	3 3/4″	3 1/4″	2 1/2″	2″	1 1/2″
H	2 5/8″	2 3/8″	2 1/8″	1 3/4″	1 3/8″	1″
I	4″	3 3/4″	3 1/4″	2 1/2″	2″	1 1/2″
K	3 1/4″	3″	2 5/8″	2 1/4″	1 7/8″	1 1/4″
L	2 7/8″	2 5/8″	2 3/8″	2″	1 5/8″	1 1/4″
M	2 7/8″×7/8″	2 5/8″×13/16″	2 3/8″×3/4″	2″×5/8″	1 5/8″×1/2″	1 1/4″×3/8″
N	2 5/8″D.×1/2″P.	2 3/8D.″×1/2″P.	2 1/8″D.×3/8″P.	1 3/4″D.×3/8″P.	1 3/8″D.×1/4″P.	1″D.×1/4″P.
O	19″	17″	15″	13 1/2″	12″	10 1/2″
P	1 3/4″	1 5/8″	1 3/8″	1 1/8″	7/8″	5/8″
Q	2 1/8″	2″	1 3/4″	1 1/2″	1 1/4″	7/8″
R	2 1/2″×11″	2 3/8″×10 1/2″	2 1/8″×9 3/4″	1 3/4″×7 7/8″	1 3/8″×7 1/2	1 1/8″×5″
S	1 7/8″	1 3/4″	1 1/2″	1 1/4″	1 1/8″	3/4″
T	2 1/4″×5 3/8″	2 1/8″×5″	2″×4 1/2″	1 3/8″×3 5/8″	1 3/8″×3 1/8″	1″×2 1/4″
U	1 7/8″	1 3/4″	1 1/2″	1 1/4″	1″	3/4″
V	3 3/4″	3 1/2″	3 1/4″	2 3/4″	2 3/8″	1 3/4″
W	4 1/8″	3 15/16″	3 1/2″	2 1/2″	2 3/8″	1 3/4″
X	2 5/8″	2 1/2″	2 1/4″	1 5/8″	1 1/2″	1 1/8′
Y	1″	7/8″	3/4″	5/8″	1/2″	3/8″
Z	20″×1 7/8″	18″×1 3/4″	16 1/2″×1 5/8″	13″×1 5/16	11 1/2″×1 1/8″	8″×7/8″

TROLLEY BLOCK.

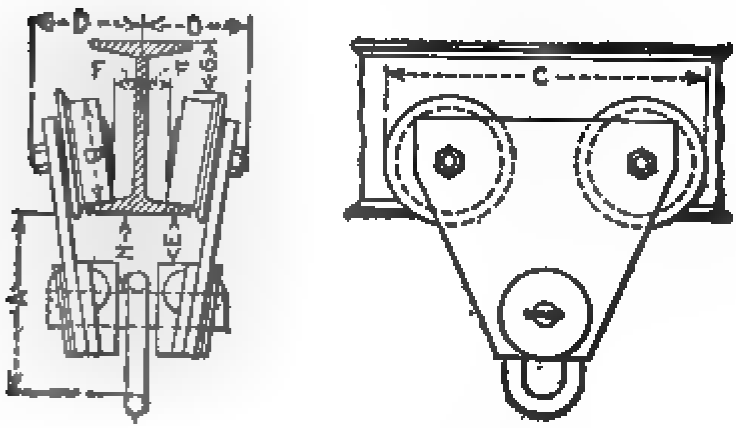


Fig. 317.

Table of Dimensions.

Cap., Tons.	Size, I	A	B	C	D	E	F	G	H	Weight.
	Ins.									Lbs.
½	5	1⅛	3¼	9	4	1⅛	¾	¾	1¾	25
1	6	6¼	3¾	12	4½	1	½	1½	2¼	40
1½	7	6¾	4¼	14	4½	1¾	¾	1¾	2	80
2	8	8½	5½	15	5	2½	1	1½	3½	120
3	9	9	6	16	6	3	1⅛	⅞	3½	135
4	10	9	6¼	16	6½	1⅞	1½	2	2¾	140
5	12	12	8	22	7½	2½	1¾	1½	4½	305
6	15	13	9	22	8	3	1½	2	5	400
8	20	17	10	28	10	3	1¾	2	6	450
10	24	18	13	28	11	3	1½	2	7	500

UNIVERSAL JOINTS.

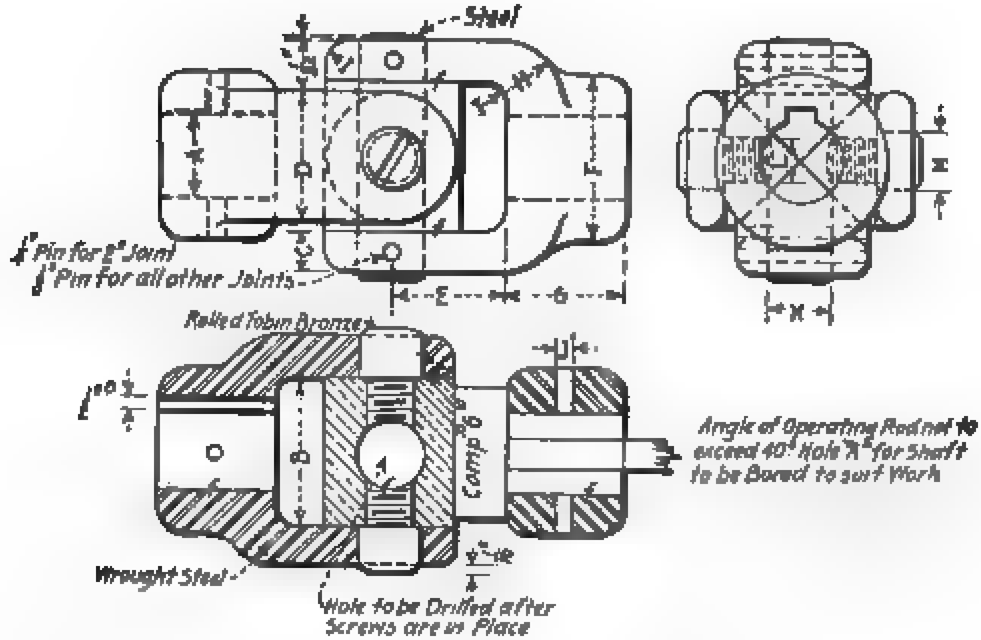


FIG. 318.

Diameter of Shaft.	Jaws.								Pins.		Screws.		Keys.
	Distance between.	Thickness.	Width.	Length.	Diameter of Hub.	Length of Hub.	Radius.	Corners and Fillets.	Diameter.	Diameter.	Diameter.	Diameter.	
A	B	C	D	E	F	G	H	I	J	K	L	M	N × O
"	"	"	"	"	"	"	"	"	"	"	"	"	" "
1/2	...	...	...	...	...	...	...	...	...	...	...	...	1/8 × 1/8
5/8	1 1/8	5/16	1	15/16	1 1/4	7/8	3/8	5/32	1/8	1/4	1/4	7/16	5/32 × 5/32
3/4	1 3/8	3/8	1 1/4	1 1/8	1 1/2	1 1/4	3/8	3/16	3/16	3/8	5/16	9/16	3/16 × 3/16
1	1 3/4	1/2	1 5/8	1 5/16	1 7/8	1 1/2	1/2	1/4	3/16	1/2	3/8	5/8	1/4 × 3/16
1 1/4	1 7/8	1/2	1 3/4	1 3/4	2 1/8	1 3/4	1/2	1/4	1/4	7/8	7/16	3/4	5/16 × 1/4
1 1/2	2 1/4	5/8	2	1 7/8	2 1/2	1 7/8	5/8	5/16	1/4	1	1/2	7/8	3/8 × 5/16
1 3/4	2 1/2	5/8	2 1/4	2	2 3/4	2	3/4	5/16	5/16	1 1/8	5/8	1	7/16 × 3/8
2	2 5/8	3/4	2 3/8	2 1/8	3	2	3/4	3/8	3/8	1 1/4	3/4	1	1/2 × 7/16

LOW PRESSURE

Size of Valve.	A	B	A_1	B_1	C	D	D_1	D_2	D_3	E	F	G	I	J	K	L	M	N	O
½	6	...	3				¼	..	.				.			...	.		.
¾	7	..	3¼				⅜		..				.	.	.	...	...	..	.
1	7½	1½	3¾	1⅛	4	2¼	1¼	.	1½		3/16	...	⅜	7/16	1⅛	..		.	.
1¼	8¼	2¼	4¼	1¼	4½	3	1⅜	..	2	.	3/16	...	⅜	7/16	1¼	...	.	...	.
1½	8¾	2½	4¾	1⅜	5	3½	1⅝	..	2¼		3/16		⅜	½	1⅜	.			..
2	10½	2¾	5¼	1½	5½	4	2¼	..	2½	⅜	3/16	.	⅜	½	1½	1¼	1½	3/16	3/16
2½	11½	3¼	5¾	1¾	6½	4¾	2¾	..	3¼	⅜	3/16		⅜	9/16	1⅝	1¼	2	3/16	3/16
3	12½	3½	6½	2⅛	7½	5½	3¼	.	4	½	¼		5/16	9/16	1¾	1⅜	2	[illegible]	3/16
3½	13	4¼	6¾	2 7/16	7¾	6¼	3¾		4½	1	¼		5/16	⅝	1⅞	1½	2¼	3/16	3/16
4	13¾	4¾	6⅞	2 11/16	8¼	7½	4½		5¼	1	¼		5/16	⅝	1⅞	1½	2⅜	¼	3/16
4½	15	5¼	7½	3	9¼	8	5	6¼	6	1⅛	¼	⅜	5/16	11/16	1¾	1⅝	2½	¼	3/16
5	16	5½	8	3½	9¾	8¾	5½	6½	6¾	1⅛	¼	⅜	5/16	¾	1⅞	1⅝	2½	¼	3/16
5½	16¾	6¼	8¾	3⅝	10½	9½	6	6¾	7	1¼	¼	11/16	5/16	¾	2	1⅝	2¾	¼	3/16
6	18	6½	9	3¾	11	10¼	6½	7¼	7½	1¼	¼	1	⅜	¾	2	1¾	2¾	5/16	3/16
6½	18¾	7¼	9½	4¼	11½	11	7¼	8	8½	1⅜	¼	1 1/16	⅜	¾	2⅛	1¾	2⅞	5/16	3/16
7	20	8	9¾	4½	13¼	11¾	7¾	8¾	9	1⅜	¼	1⅛	⅜	⅞	2¼	1¾	2⅞	5/16	3/16
7½	21¼	8⅝	10	4⅝	13½	12¾	8¼	9¼	9½	1½	¼	1¼	⅜	⅞	2¼	1⅞	3	5/16	3/16
8	22¾	9¼	10¾	5	14¼	13½	9	9¾	10	1⅝	¼	1 5/16	½	⅞	2⅜	1⅞	3	⅜	3/16
8½	24	9¾	10¾	5¼	14⅞	14½	9½	10¼	10⅝	1½	¼	1 7/16	½	⅞	2½	1⅞	3¼	⅜	3/16
9	25½	10¼	11¼	5½	15¾	15	10	11	11⅛	1⅝	¼	1½	½	15/16	2½	1⅞	3¼	⅜	3/16
9½	26¾	10¾	11⅝	5⅞	16	15½	10½	11½	11½	1¾	¼	1 7/16	½	15/16	2⅝	2	3⅜	⅜	3/16
10	28	11¼	12	6¼	16⅝	16½	11	12	12½	2	¼	1½	½	15/16	2¾	2	3½	⅜	3/16
10½	29½	11¾	12½	6¾	17½	17½	11½	12½	12¾	2	¼	1½	½	15/16	2¾	2	3⅝	⅜	3/16
11	30½	12¼	13	6⅝	17¾	18	12	13	13¼	2	¼	1½	½	1	2⅞	2¼	3¾	⅜	3/16
11½	31¾	12¾	13¼	6⅞	19	18¾	12½	13½	13¾	2⅛	¼	1⅝	½	1	3	2¼	4	⅜	3/16
12	33	13	13⅝	7¼	19⅝	19½	13¼	14¼	14¾	2¼	¼	1⅝	½	1	3	2⅜	4	7/16	3/16
12½	34½	13¾	14¼	7½	20¼	20¼	13¾	14¾	14⅞	2¼	¼	1⅝	½	1	3¼	2½	4¼	7/16	3/16
13	36	13¾	14¾	7¾	20⅝	21	14¼	15½	15⅝	2¼	¼	1¾	½	1	3⅜	2⅝	4⅜	7/16	3/16
13½	37½	14¼	15¼	8	21½	21¾	14¾	15¾	15⅞	2¼	¼	1¾	½	1	3½	2⅝	4½	½	3/16
14	39	14½	16¼	8¼	21¾	22½	15½	16⅛	16⅛	2½	¼	1¾	½	1	3½	3	4⅝	½	3/16
14½	40½	15	16½	8¾	22¼	23½	15¾	16¾	17¼	2½	¼	1⅞	½	1	3⅝	3	4¾	½	3/16
15	42	15½	16¾	9	22¾	24	16¼	17⅜	17¾	2½	¼	1⅞	½	1	3¾	3	4⅞	½	3/16

VALVES.

P	Q	R	S	T	U	X	Pitch Circle.	No Studs in Cover.	Diam. Studs in Cover.	No Ribs in Cover.	Thickness Ribs in Cover.	No Ribs Under Valve Seat.	Thickness Ribs Under Valve Seat.	a	b	c	d	e	f
				5/16															
..				3/16															
		3 3/16	3/16	3/16		1/4	2 3/4	6	3/8										
		4	3/16	3/16		1/4	3 1/4	6	3/8										
		4 5/16	3/16	3/16		1/4	3 3/4	6	3/8										
1 1/4	3 1/2	6	3/16	3/16		5/16	4 3/4	6	3/8					1	5/16	1/4	5/16	2 1/4	1 1/2
1 1/4	3 3/4	6 3/4	3/16	3/16		5/16	4 3/4	6	3/8					1	5/16	5/16	1/4	2 5/16	1 5/8
1 1/2	4 1/4	7 1/2	3/16	1/4		5/16	5 1/2	6	3/8	4	3/16			1	5/16	5/16	1/4	2 7/16	1 3/4
1 1/2	4 3/4	8 1/2	3/16	1/4		3/8	6 1/4	6	3/8	4	3/16			1	3/8	5/16	3/8	2 1/2	2
1 1/2	5 1/4	9 1/2	3/16	1/4	1 1/4	3/8	6 3/4	6	3/8	4	3/16	3	1/2	1	3/8	5/16	3/8	2 1/2	2
1 1/2	5 3/4	10 1/2	3/16	1/4	1 1/4	3/8	7 1/2	8	3/8	4	3/16	3	1/2	1 1/8	3/8	[illegible]	3/8	2 5/8	2 1/8
1 5/8	6 1/4	11 1/2	5/16	5/16	1 1/4	3/8	8	8	3/8	4	1/4	3	1/2	1 1/8	3/8	5/16	3/8	2 3/4	2 1/4
1 3/4	6 3/4	12 1/4	5/16	5/16	1 1/4	7/16	8 3/4	10	3/8	4	1/4	3	1/2	1 1/4	3/8	3/8	3/8	3	2 1/4
1 3/4	7 1/4	13 1/2	1/4	5/16	1 1/4	7/16	9 1/4	10	3/8	4	1/4	3	1/2	1 1/4	3/8	3/8	3/8	3	2 3/8
1 7/8	7 3/4	14 3/4	1/4	5/16	1 3/8	1/2	10 1/2	12	3/8	4	1/4	3	1/2	1 1/4	3/8	3/8	3/8	3 1/4	2 3/8
1 7/8	8 1/4	15 1/2	1/4	3/8	1 1/2	1/2	[illegible]	12	3/8	4	1/4	3	1/2	1 1/4	3/8	3/8	3/8	3 1/4	2 1/2
2	8 3/4	16 1/2	1/4	3/8	1 1/2	9/16	11 3/4	12	3/8	4	1/4	3	1/2	1 3/8	3/8	3/8	3/8	3 3/8	2 1/2
2	9	17 1/2	1/4	3/8	2 1/4	1/2	12 1/2	14	1/2	4	1/4	3	1/2	1 3/8	3/8	1/2	3/8	3 1/2	2 3/4
2 1/8	9 1/2	18 1/2	1/4	3/8	2 1/4	1/2	13 1/4	14	1/2	4	1/4	3	1/2	1 3/8	3/8	1/2	3/8	3 5/8	2 3/4
2 1/4	10	20	1/4	7/16	2 1/4	9/16	13 3/4	14	1/2	4	5/16	3	1/2	1 3/8	3/8	1/2	3/8	3 3/4	2 7/8
2 3/8	10 1/2	21	1/4	7/16	2 3/8	9/16	14 1/4	16	1/2	4	5/16	3	1/2	1 1/2	1/2	1/2	1/2	4 1/4	3 1/8
2 3/8	11	22	1/4	7/16	2 3/8	5/8	14 3/4	16	1/2	4	5/16	3	1/2	1 1/2	1/2	1/2	1/2	4 1/4	3 1/4
2 1/2	11 1/2	23	1/4	7/16	2 3/8	5/8	15 1/4	18	1/2	4	5/16	3	1/2	1 1/2	1/2	1/2	1/2	4 1/2	3 1/4
2 1/2	12	24	1/4	1/2	2 3/8	5/8	16	18	1/2	4	5/16	3	1/2	1 1/2	1/2	5/8	1/2	4 5/8	3 1/2
3	12 1/2	25	1/4	1/2	2 1/2	5/8	17	18	1/2	4	5/16	3	1/2	1 5/8	1/2	5/8	1/2	4 3/4	3 1/2
3	13	26 1/2	1/4	1/2	2 1/2	5/8	17 3/4	18	1/2	4	3/8	4	1/2	1 5/8	1/2	5/8	1/2	4 7/8	3 5/8
3 1/8	13 1/2	28	1/4	1/2	2 1/2	5/8	18 1/4	20	1/2	4	3/8	4	1/2	1 5/8	1/2	5/8	1/2	4 7/8	3 3/4
3 1/4	14	28 1/2	1/4	9/16	2 1/2	5/8	18 3/4	20	1/2	4	3/8	4	1/2	1 5/8	5/8	1	5/8	5 1/4	3 3/4
3 3/8	14 1/2	29	1/4	9/16	2 1/2	5/8	19 1/4	20	1/2	4	3/8	4	1/2	1 5/8	5/8	1	5/8	5 1/2	3 7/8
3 3/8	15	31	1/4	5/8	2 5/8	5/8	19 3/4	20	1/2	4	3/8	4	1/2	1 3/4	5/8	1	5/8	5 1/2	3 7/8
3 1/2	15 1/2	32	1/4	5/8	2 3/4	5/8	20 1/4	20	1/2	4	3/8	4	1/2	1 3/4	5/8	1	5/8	5 3/4	4
3 1/2	16	33	1/4	5/8	2 3/4	5/8	30 1/4	22	1/2	4	3/8	4	1/2	1 3/4	5/8	1	5/8	5 3/4	4

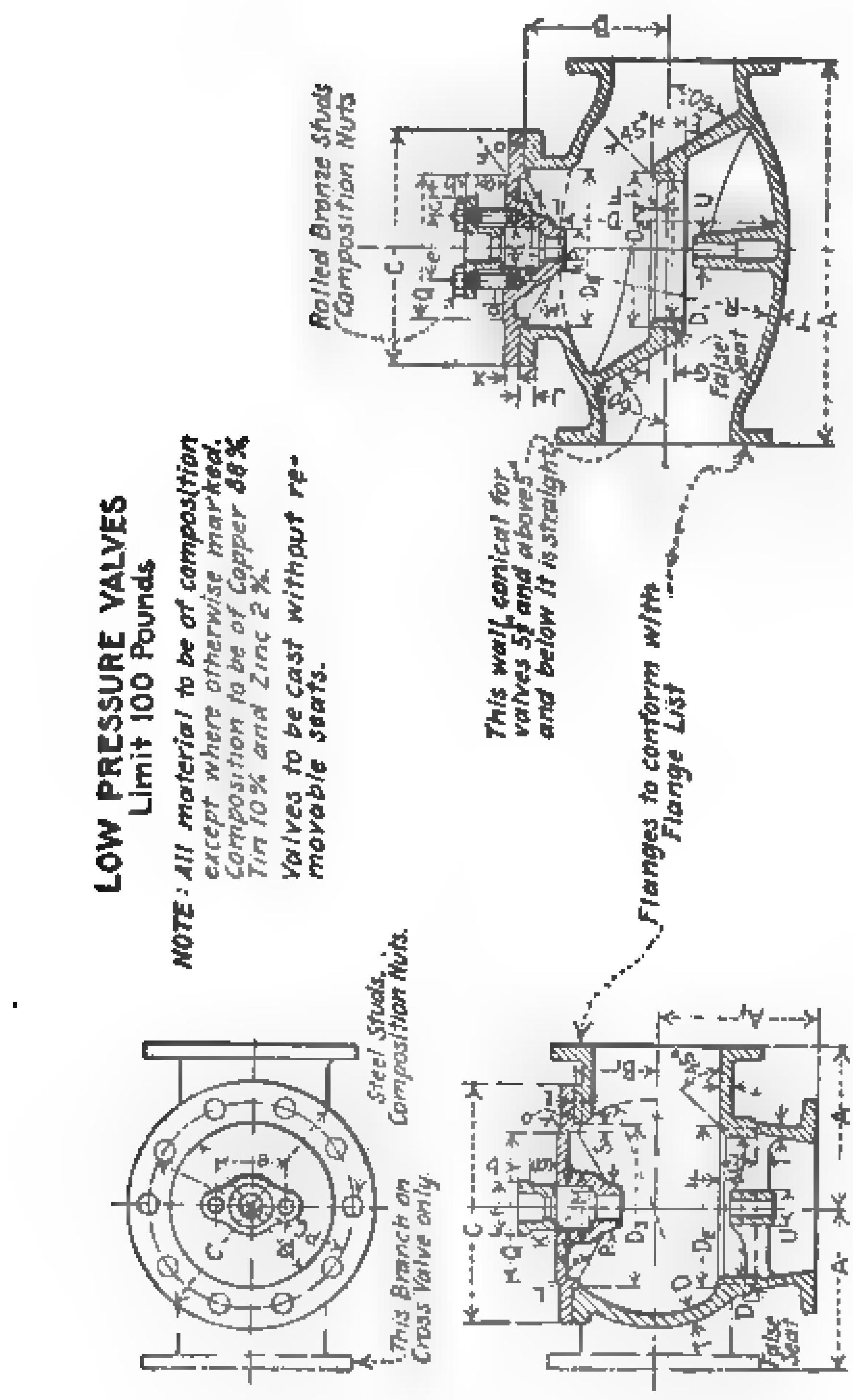

LOW PRESSURE VALVES
Limit 100 Pounds
NOTE: All material to be of composition except where otherwise marked. Composition to be of Copper 88% Tin 10% and Zinc 2%.
Valves to be cast without removable seats.
Rolled Bronze Studs Composition Nuts
This wall conical for valves 5" and above and below it is straight.
Flanges to conform with Flange List
Steel Studs, Composition Nuts.
This Branch on Cross Valve only
False Seat

FIG. 318.

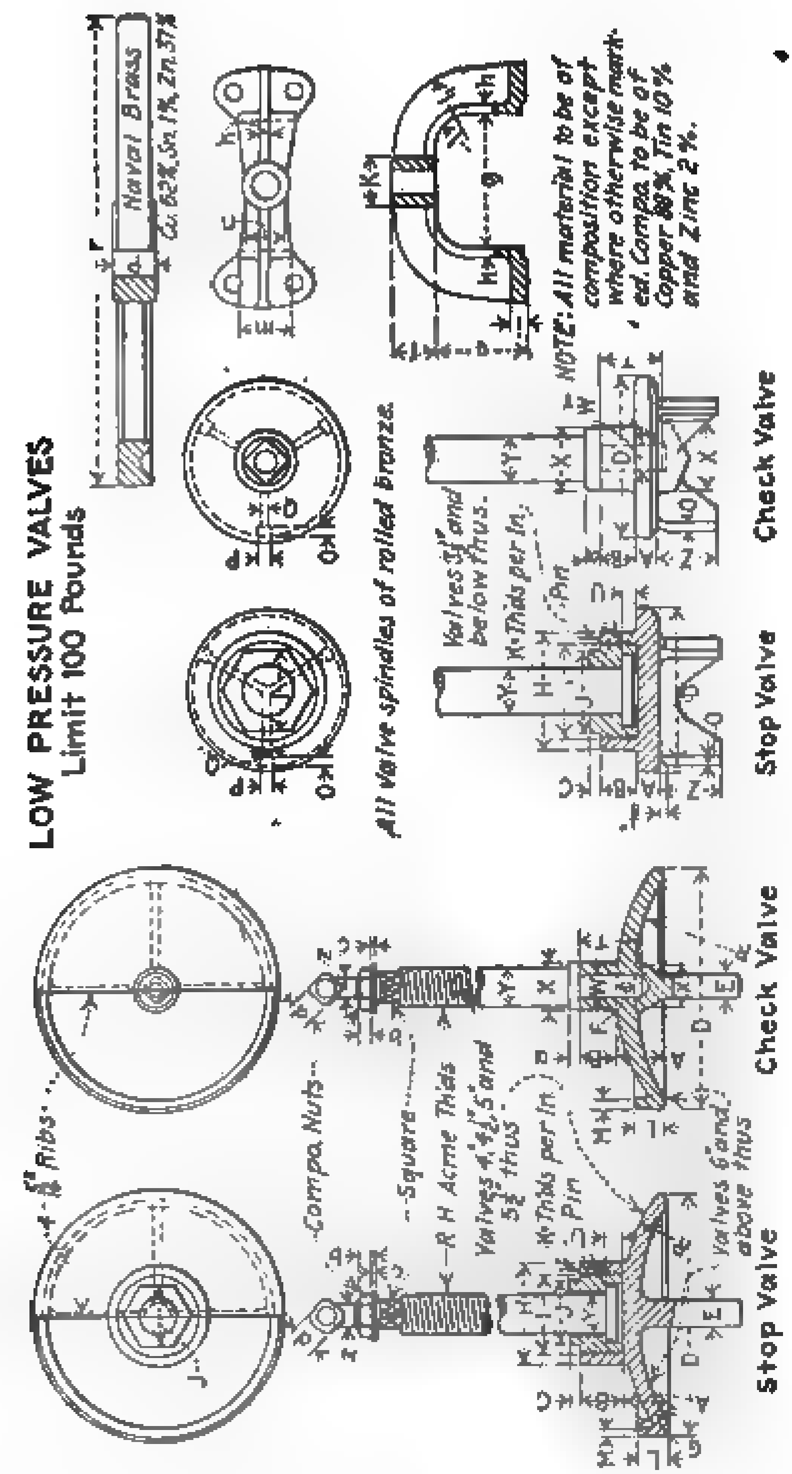

LOW PRESSURE VALVES
Limit 100 Pounds
Stop Valve
Check Valve
Stop Valve
Check Valve
All valve spindles of rolled bronze.
Naval Brass
Cu. 62%, Sn. 1%, Zn. 37%
Compo. Nuts
Square
R H Acme Thds
NOTE: All material to be of composition except where otherwise marked. Compo. to be of Copper 88%, Tin 10% and Zinc 2%.

FIG. 320.

LOW PRESSURE

Size of Valve.	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	T	U
⅜	¼			13/16																
½	¼			1 1/16																
1	¼	¼	5/16	1⅛							16			¼	¼	3/16	¼		13/16	¼
1¼	5/16	¼	5/16	1½							16			¼	¼	3/16	¼		¾	5/16
1½	5/16	¼	5/16	2							16			¼	¼	3/16	¼		13/16	⅜
2	5/16	¼	5/16	2½				2¼	1½	1⅛	14			1	5/16	⅜	5/16		15/16	7/16
2½	⅜	¼	⅜	3¼				2¼	1⅝	1 7/16	14			1⅛	5/16	⅜	5/16		1⅛	7/16
3	7/16	⅜	⅜	3¾				2½	1¾	1½	14			1¼	⅜	⅜	[illegible]		1¼	½
3½	½	⅜	⅜	4¼				2½	1⅞	1⅝	14			1⅜	⅜	⅜	7/16		1⅜	½
4	1⅛	⅜	⅜	4¾	⅜	½	½	2¾	2⅛	1¾	14							4	1½	⅝
4½	1¼	½	⅜	5¼	⅜	½	½	3	2¼	2	12							4½	1⅝	⅝
5	1 5/16	1	½	5¾	⅜	½	½	3	2	2	12							5	1 13/16	⅝
5½	1⅜	1⅛	½	6¼	⅞	7/16	½	3¼	2½	2 5/16	12							5½	1⅞	7/16
6	1½	1⅜	½	6¾	⅞	½	⅝	3½	2½	2 7/16	12	1	⅜					6	2	9/16
6½	1½	1½	½	7¼	1	½	7/16	3¾	2⅝	2 9/16	12	1	⅜					6½	2 1/16	⅝
7	1⅝	1⅝	½	8¼	1	½	7/16	3¾	2⅞	2 9/16	12	1⅛	⅜					7	2 3/16	⅝
7½	1 11/16	1⅝	½	8¾	1	⅝	9/16	4	3⅛	2¾	12	1⅛	7/16					7½	2⅜	9/16
8	1¾	1⅝	½	9½	1⅛	⅝	7/16	4	3¼	2⅞	12	1¼	7/16					8	2½	9/16
8½	1⅞	1⅝	½	10	1⅛	⅝	7/16	4¼	3½	2 15/16	12	1¼	7/16					8½	2⅝	⅝
9	1 15/16	1¾	½	10½	1¼	11/16	[illegible]	4½	3½	2 15/16	12	1⅜	7/16					9	2⅞	11/16
9½	2	1¾	½	11	1¼	¾	½	4¾	3⅝	3⅛	12	1½	½					9½	3	11/16
10	2⅛	1⅞	½	11½	1¼	¾	½	4⅞	3¾	3⅛	12	1½	½					10	3	¾
10½	2¼	1⅞	½	12	1⅜	13/16	½	4⅞	3⅞	3¼	12	1⅝	½					10½	3¼	¾
11	2¼	2	½	12½	1½	13/16	9/16	4⅞	3⅞	3¼	12	1⅝	9/16					11	3⅜	¾
11½	2⅜	2	½	13	1½	13/16	9/16	5	4	3⅛	10	1¾	9/16					11½	3½	13/16
12	2½	2	½	13½	1⅝	⅞	⅝	5	4	3⅛	10	1¾	⅝					12	3½	13/16
12½	2⅝	2	½	14¼	1¾	⅞	⅝	5⅛	4¼	3½	10	1⅞	11/16					12½	3⅝	13/16
13	2¾	2⅛	½	14¾	1⅞	⅞	⅝	5¼	4¼	3½	10	2	¾					13	3⅞	⅞
13½	2⅞	2¼	½	15¼	1⅞	⅞	11/16	5⅜	4⅜	3⅝	10	2	¾					13½	4⅛	⅞
14	3	2⅜	½	15¾	1⅞	⅞	11/16	5½	4½	3¾	10	2⅛	¾					14	4¼	⅞
14½	3⅛	2½	½	16¼	1⅞	⅞	13/16	5½	4½	3⅞	10	2¼	¾					14½	4⅜	15/16
15	3¼	2½	½	16¾	[illegible]	⅞	13/16	5¾	4½	3⅞	10	2¼	¾					15	4½	15/16

VALVES.

V	W	X	Y	Z	No. Threads on Spindle.	a	b	c	d	e	f	g	h	i	k	l	l_1	m	n	p	r
			3/8		9															3/8	2
			3/8		8															7/16	3
13/16	3/8		3/8	5/16	7	5/16	1/4		3/8	1 7/8	1		1/4	1/4	1 3/8	3/8	1 1/2	1 1/2	1 1/4	7/16	3
15/16	3/8		3/8	5/16	7	5/16	1/4		1/2	2	1		1/4	3/8	1 1/4	3/8	1 1/2	1 3/4	1 1/4	1/2	4
1 1/16	1/2		1/2	3/8	6	5/16	5/16		7/16	2 1/16	1 1/4		1/4	7/16	1 1/4	1/2	1 1/2	1 1/2	1 1/4	1/2	4
1 1/8	1/2	1 1/16	1/2	3/8	6	5/16			7/16	2 1/4	1 1/4	2 1/2	1/4	7/16	1 1/4	1/2	1 1/2	1 1/2	1 5/16	1/2	5
1 1/4	1/2	1 1/4	1/2	1/2	6	1/4	3/8		7/16	2 1/2	1 3/8	2 7/8	1/4	7/16	1 3/8	1/2	1 3/4	1 3/4	1 3/4	11/16	6
1 3/8	1/2	1 3/8	5/8	1/2	6	1/4	3/8		7/16	2 3/4	1 1/2	3 1/4	1/4	7/16	1 1/2	1/2	1 3/4	1 3/4	1 3/4	11/16	6
1 1/2	5/8	1 1/2	1	1/2	5	1/4	3/8		7/16	3	1 5/8	3 3/4	1/4	1/4	1 7/8	5/8	2 1/4	1 7/8	1 3/4	3/4	7
1 5/8	5/8	1 5/8	1	1/2	5	1/4	3/8		9/16	3 1/4	1 3/4	4 1/4	1/4	1/4	1 7/8	3/4	2 1/2	1 7/8	1 3/4	3/4	8
1 3/4	5/8	1 3/4	1 1/8	1/2	5	1/4	3/8		11/16	3 1/2	1 7/8	4 3/4	1/4	1/4	2	1	2 3/4	2	1 3/4	3/4	8
1 3/4	3/4	1 3/4	1 1/8	1/2	5	3/8	3/8		13/16	3 7/16	1 7/8	5 1/4	5/16	5/16	2	1 1/4	2 3/4	2 1/4	1 3/4	13/16	9
1 7/8	3/4	1 7/8	1 1/4	5/8	4	3/8	3/8		3/4	3 3/4	2	5 1/2	5/16	5/16	2 1/8	1 1/4	3	2 1/4	1 3/4	1	10
1 7/8	7/8	1 7/8	1 1/4	5/8	4	3/8	3/8		3/4	4	2	6	3/8	11/16	2 1/4	1 1/4	3 1/4	2 1/2	1 7/8	1	10
2	1	1 7/8	1 3/8	5/8	4	3/8	3/8		13/16	4 1/4	2 1/8	6 1/4	3/8	3/8	2 1/8	1 1/2	3 5/8	2 1/2	2	1 1/16	11
2	1	1 7/8	1 1/2	5/8	4	3/8	3/8		13/16	4 1/2	2 1/4	6 3/4	3/8	3/8	2 1/4	1 3/4	3 3/4	2 5/8	2	1 1/8	12
2 1/4	1	1 7/8	1 1/2	3/4	4	3/8	3/8		15/16	4 1/2	2 1/2	7 1/2	3/8	3/8	2 1/4	1 7/8	4 1/2	2 5/8	2 1/4	1 1/8	12
2 1/4	1 1/8	2	1 1/2	3/4	4	3/8	3/8		15/16	4 3/4	2 1/2	7 3/4	3/8	3/8	2 1/2	2	4 1/2	2 1/2	2 1/2	1 3/16	14
2 3/8	1 1/4	2	1 5/8	3/4	4	3/8	11/16	5/32	1	5	2 5/8	8 1/4	3/8	3/8	2 1/2	2 1/4	4 3/4	2 1/2	2 1/2	1 3/16	14
2 3/8	1 1/4	2	1 5/8	7/8	4	1/2	7/16	5/32	1	5 1/4	2 3/4	8 3/4	3/8	3/8	2 3/4	2 1/4	4 3/4	2 1/2	2 1/2	1 3/16	14
2 5/8	1 1/4	2 1/4	1 3/4	7/8	4	1/2	9/16	3/16	1	5 3/4	3	9 1/4	3/8	3/8	3	2 3/4	5 1/4	2 3/4	2 3/4	1 5/16	16
2 5/8	1 1/4	2 1/4	1 3/4	7/8	4	1/2	9/16	3/16	1	5 1/2	3	9 1/2	3/8	3/8	3	2 1/2	5 1/2	2 3/4	2 3/4	1 5/16	16
2 3/4	1 3/8	2 1/2	1 7/8	1	4	1/2	1/2	3/16	1 3/16	5 3/4	3 1/4	10	1/2	1/2	3 1/4	2 3/4	5 3/4	2 3/4	2 3/4	1 5/16	16
2 3/4	1 3/8	2 1/2	1 7/8	1	4	1/2	1/2	3/16	1 3/16	5 3/4	3 1/4	10 1/4	1/2	1/2	3 1/4	2 3/4	5 3/4	3	3	1 3/8	18
2 7/8	1 1/2	2 3/4	2	1	4	1/2	1/2	3/16	1 3/16	5 7/8	3 1/2	10 3/4	1/2	1/2	3 1/2	[illegible]	6 1/4	3 1/4	3 1/4	1 3/8	18
2 7/8	1 1/2	2 3/4	2	1	4	1/2	1/2	3/16	1 3/16	6	3 1/2	11 1/4	1/2	1/2	3 1/2	3 1/4	6 1/4	3 1/4	3 1/4	1 3/8	18
3 1/8	1 1/2	2 3/4	2 1/4	1 1/8	4	1/2	1/2	3/16	1 1/4	6 1/16	3 3/4	11 3/4	1/2	1/2	3 3/4	3 1/4	6 3/4	3 1/2	3 1/2	1 1/2	21
3 1/4	1 1/2	2 3/4	2 1/4	1 1/8	4	1/2	1/2	3/16	1 1/4	6 1/4	3 3/4	12 1/4	1/2	1/2	4 1/4	3 1/2	6 3/4	3 3/4	3 1/2	1 1/2	21
3 3/8	1 1/2	2 3/4	2 3/8	1 1/4	4	1/2	13/16	3/16	1 1/4	6 1/2	3 7/8	12 3/4	1/2	1/2	4 1/4	3 3/4	7 1/4	4	4	1 1/2	21
3 3/8	1 5/8	3	2 3/8	1 1/4	4	1/2	13/16	3/16	1 1/4	6 1/2	3 7/8	13 1/4	1/2	1/2	4 1/2	4	7 1/2	4 1/4	4 1/4	1 1/2	21
3 1/2	1 5/8	3	2 1/2	1 1/4	4	1/2	13/16	3/16	1 1/4	6 3/4	4	13 1/2	1/2	1/2	4 1/2	4	7 3/4	4 1/2	4 1/2	1 1/2	21
3 1/2	1 5/8	3	2 1/2	1 1/4	4	1/2	13/16	[illegible]	1 1/4	6 3/4	4	14	1/2	1/2	4 1/2	4	7 3/4	4 1/2	4 1/2	2 1/16	24

HEAVY PRESSURE

Size of Valve.	A	B	A_1	B_1	C	D	D_1	D_2	D_3	E	F	G	H	I	J	K	L	M	N	O	P	Q
½	6	1½	3	1	3½	.	⅜		.	.				⅛	.				...	.	..	...
¾	7	1⅝	3⅜	1⅛	4⅛		⅞	.				.		⅛			.		..		..	..
1	7½	1⅝	3⅝	1⅜	4⅝	2⅝	1⅛	.			3/16			⅛	.	1½			.	.	...	...
1¼	8½	2⅛	4½	1½	5¼	3	1⅜			.	3/16			⅛	.	1½	.		..	.	...	...
1½	8⅞	2⅛	4⅝	1⅝	5⅝	3⅛	1⅞				3/16			⅛	.	1½						...
2	10½	2⅞	5⅛	1⅞	6⅛	4	2⅛		3⅝	⅞	3/16		4½	⅛	¼	1½	1½	2⅛	3/16	3/16	1⅝	4
2½	11½	3⅛	5⅝	2⅛	7½	4⅝	2⅞		3⅝	⅞	3/16		5⅛	⅛	¼	1½	1⅝	2⅜	¼	3/16	1⅝	4⅝
3	12½	3⅝	6⅛	2⅜	8⅛	5⅜	3⅛	.	4	⅞	¼		5½	3/16	¼	1⅞	1½	2⅜	⅜	3/16	1⅝	5⅝
3½	13	4½	6⅜	2⅞	8⅞	6⅛	3⅝		4½	1	¼		6⅛	3/16	⅜	2	1⅝	2⅞	⅜	[illegible]	1⅞	5⅝
4	13⅞	4⅝	6⅞	3⅛	9⅛	7½	4⅛		5⅛	1	¼		6⅞	3/16	⅜	2⅛	1⅝	2⅞	11/16	3/16	2	6⅛
4½	15	5½	7⅜	3⅜	10⅛	8	5	5⅞	6	1⅛	¼	⅞	7⅞	3/16	⅜	2⅛	1⅞	3⅛	11/16	3/16	2⅛	7⅛
5	16	5⅞	8	3⅞	11⅛	8⅝	5⅜	6½	6⅜	1⅛	¼	⅞	8½	3/16	1⅛	2⅝	2	3⅛	¾	3/16	2⅛	7⅝
5½	16⅞	6½	8⅜	4⅛	12	9⅜	6	6⅞	7	1⅛	¼	15/16	8⅞	3/16	1⅛	2½	2⅜	3⅛	¾	3/16	2⅜	8
6	18	6⅞	9	4⅜	12⅝	10½	6⅜	7⅞	7½	1½	¼	1	9⅝	3/16	1⅛	2⅞	2½	3⅞	¾	3/16	2⅜	8⅝
6½	18⅞	7⅛	9⅜	4⅞	13½	11	7⅛	8	8½	1⅝	¼	1 1/16	10⅛	3/16	1⅛	2⅞	2⅝	3⅞	13/16	3/16	2⅞	9⅝
7	20	8	9⅝	5	14	11⅞	7⅞	8⅝	9	1⅜	¼	1⅛	10⅞	3/16	1⅛	3	2⅝	4	13/16	3/16	2⅞	10
7½	21½	8⅝	10	5½	14⅝	12⅝	8½	9⅛	9½	1⅛	¼	1⅛	11⅛	3/16	1⅛	3½	2⅞	4⅛	⅞	3/16	3⅛	10⅛
8	22⅞	9⅛	10⅞	5⅝	15⅛	13⅜	9	9⅞	10	1⅝	¼	1 1/16	11⅞	3/16	1⅛	3⅞	3	4⅛	⅞	⅜	3⅛	10⅞
8½	24	9⅝	10⅞	5⅞	16	14½	9⅝	10⅝	10⅞	1⅜	¼	1 3/16	12⅛	3/16	1⅛	3⅜	3	4⅛	⅞	⅜	3⅜	11⅜
9	25⅛	10⅛	11⅛	6	16⅝	15	10	11	11⅞	1⅞	¼	1⅝	13	[illegible]	1⅛	3⅞	3	4⅞	15/16	⅜	3⅜	12
9½	26⅞	10⅞	11⅞	6⅛	17⅛	16⅞	10⅛	11⅛	11⅞	1⅞	¼	1 3/16	13⅞	3/16	1⅛	3⅞	3½	5⅛	15/16	⅜	3⅜	12⅛
10	28	11½	12	6⅛	18	16⅛	11	12	12⅛	2	5/16	1⅛	14⅛	3/16	1⅛	3⅞	3⅞	5⅛	1	⅜	3⅜	12⅞
10½	29½	11⅞	12⅜	6⅞	18⅞	17½	11⅜	12⅛	12⅞	2	5/16	1⅜	14⅞	3/16	1⅜	4	3⅜	5⅞	1	⅜	3⅞	13⅜
11	30⅛	12⅛	13	7	19⅛	18	12	13	13½	2	5/16	1⅛	15⅛	3/16	1⅛	4⅛	3⅜	5⅛	1 1/16	⅜	4	14⅛
11½	31⅞	12⅞	13½	7¼	20	18½	12⅛	13⅞	13⅞	2⅛	5/16	1⅜	16	3/16	1⅜	4⅛	3⅞	5⅞	1 1/16	⅜	4⅛	14⅞
12	33	13	13⅞	7½	20⅜	19⅛	13⅛	14⅛	14⅞	2⅛	5/16	1⅞	16⅞	3/16	1⅛	4⅜	3⅞	6	1 1/16	⅜	4⅞	15⅞
12½	34⅛	13⅝	14½	7⅞	21⅛	20⅜	13⅝	14½	14⅞	2⅛	⅜	1⅜	17⅛	3/16	1⅛	4⅝	3½	6⅛	1⅛	⅜	4⅜	15⅞
13	36	13⅞	14⅞	8	22⅛	21	14⅛	15¼	15⅞	2⅛	⅜	1⅝	17⅞	3/16	1⅛	4⅞	4	6⅛	1⅛	⅜	4⅝	16⅝
13½	37½	14⅛	15⅛	8⅛	23	21⅞	14⅝	15⅞	15⅞	2⅛	⅜	1⅝	18⅝	3/16	1⅛	4⅞	4	6⅛	1 3/16	⅜	4⅞	17⅛
14	39	14⅛	15⅞	8⅜	23⅞	22½	15½	16⅞	16⅞	2⅛	⅜	1⅞	19⅛	3/16	1⅛	5	4	6⅝	1 3/16	⅜	4⅞	18
14½	40½	15	16½	8⅝	24⅛	23⅛	15⅝	16⅞	17⅛	2⅛	⅜	1⅞	19⅞	3/16	1⅛	5⅛	4⅜	6⅞	1 3/16	⅜	5⅛	18⅛
15	42	15⅛	16⅞	9½	24⅞	24	16⅛	17⅞	17⅛	2⅛	⅜	1⅞	20⅞	3/16	1⅛	5½	4½	7	1¼	⅜	5⅛	19

VALVES.

R	R_1	S	T	U	V	W	X	Pitch Circle.	No Studs in Cover.	Diam. Studs in Cover.	No. Ribs in Cover.	Thickness Ribs in Cover.	No. Ribs Under Valve Seat.	Thickness Ribs Under Valve Seat.	a	b	c	d	e	f
3 5/16			1/4																	
4			1/4																	
4 5/16			3/8																	
6	3/8	1 1/8	5/16		5/8	3	3/8	5 3/4	6	5/8					7/8	7/16	1/2	7/16	2 7/16	1 7/8
6 3/4	3/8	1 1/4	3/8		5/8	3 1/4	3/8	6	6	5/8					1	1/2	[illegible]	1/2	2 1/2	2
7 3/4	3/8	1 3/8	3/8		3/4	3 1/2	1/2	6 1/2	6	3/4	4	3/8			1 1/8	1/2	[illegible]	1/2	2 3/4	2 1/4
8 3/4	3/8	1 1/2	7/16		3/4	3 3/4	1/2	7 1/4	8	3/4	4	3/8			1 1/4	1/2	1/2	5/8	3	2 1/2
9 3/4	7/16	1 5/8	7/16	1 1/8	7/8	4 1/4	1/2	7 3/4	10	3/4	4	3/8	3	3/8	1 1/4	1/2	1/2	5/8	3 1/4	2 1/2
10 3/4	1	1 7/8	1/2	1 1/4	1	4 1/2	1/2	8 7/8	10	3/4	4	3/8	3	3/8	1 1/4	1/2	5/8	5/8	3 1/2	2 3/4
11 3/4	1	2 1/8	1/2	1 1/2	1 1/8	5 1/4	1/2	9 1/4	10	7/8	4	3/8	3	3/8	1 1/2	1/2	5/8	5/8	3 3/4	2 3/4
12 3/4	1	2 1/4	9/16	1 1/2	1 1/4	5 1/2	5/8	10	10	7/8	4	3/8	3	3/8	1 1/2	5/8	5/8	5/8	3 3/4	2 7/8
13 3/4	1/2	2 3/8	9/16	1 1/2	1 1/4	5 3/4	5/8	10 3/8	10	7/8	4	7/16	3	7/16	1 1/2	5/8	3/4	3/4	4 1/4	3
14 3/4	1/2	2 1/2	5/8	1 5/8	1 1/2	6 1/4	7/8	11 1/4	12	7/8	4	7/16	3	7/16	1 5/8	5/8	7/8	3/4	4 1/2	3 1/4
15 3/4	1/2	2 5/8	5/8	1 3/4	1 3/4	6 1/2	7/8	12	12	7/8	4	1/2	3	[illegible]	1 3/4	5/8	7/8	3/4	4 1/2	3 1/2
16 3/4	1/2	2 7/8	11/16	1 7/8	1 1/2	6 3/4	1	12 3/4	12	1	4	1/2	3	1/2	1 3/4	5/8	1	3/4	4 3/4	3 1/2
17 3/4	1/2	2 7/8	11/16	2 1/8	1 1/2	7 1/4	1	13 1/4	12	1	4	1/2	3	1/2	1 3/4	3/4	1	3/4	5 1/4	3 3/4
18 3/4	1/2	3 1/8	3/4	2 1/4	1 5/8	7 1/2	1	13 3/4	14	1	4	1/2	3	1/2	1 3/4	3/4	1	3/4	5 1/2	3 7/8
20	1/2	3 1/4	3/4	2 1/4	1 3/4	7 3/4	1	14 1/4	14	1	4	1/2	3	1/2	1 3/4	3/4	1	3/4	5 3/4	4
21	1/2	3 1/2	3/4	2 3/8	1 7/8	8 1/4	1 1/8	15	14	1 1/8	4	5/8	3	1/2	1 7/8	3/4	1	3/4	5 3/4	4 1/4
22		3 5/8	13/16	2 1/2	1 7/8	9	1 1/8	15 1/2	14	1 1/8	4	5/8	3	5/8	1 7/8	3/4	1	3/4	5 7/8	4 1/2
23		3 3/4	13/16	2 1/2	2	9	1 1/4	16 1/4	16	1 1/4	4	5/8	3	5/8	1 7/8	1	1 1/8	1	5 7/8	4 1/2
24		3 7/8	7/8	2 1/2	2	9 1/2	1 1/4	17	16	1 1/4	4	3/4	3	3/4	1 7/8	1	1 1/8	1	6	4 1/2
25		4 1/8	7/8	2 5/8	2 1/8	10	1 5/16	17 1/2	16	1 1/4	4	3/4	3	3/4	1 7/8	1	1 1/4	1	6 1/4	4 3/4
26 1/2		4 1/4	15/16	2 5/8	2 1/4	10	1 5/16	18 1/4	16	1 1/4	4	3/4	4	3/4	1 7/8	1	1 1/4	1	6 1/2	4 7/8
28		4 1/2	1	2 5/8	2 1/4	10 1/2	1 5/16	18 3/4	18	1 1/2	4	3/4	4	3/4	1 7/8	1	1 3/8	1	6 1/2	5
28 1/2		4 5/8	1	2 5/8	2 1/4	11	1 3/8	19 1/4	18	1 1/2	4	3/4	4	3/4	1 7/8	1	1 3/8	1	6 3/4	5
29		4 3/4	1 1/16	2 3/4	2 3/8	11 1/4	1 1/2	20 1/4	18	1 1/2	4	3/4	4	7/8	1 7/8	1	1 1/2	1	6 3/4	5 1/4
31		4 7/8	1 1/16	2 3/4	2 1/2	11 1/2	1 1/2	21	18	1 1/2	4	7/8	4	7/8	1 7/8	1	1 1/2	1	6 7/8	5 1/2
32		5	1 1/8	2 3/4	2 1/2	12 1/4	1 1/2	21 1/2	18	1 1/2	4	7/8	4	7/8	2	1	1 1/2	1	7 1/4	5 1/2
33		5	1 1/8	2 7/8	2 1/2	13	1 5/8	22	18	1 1/2	4	7/8	4	7/8	2	1	1 1/2	1	7 1/2	5 3/4

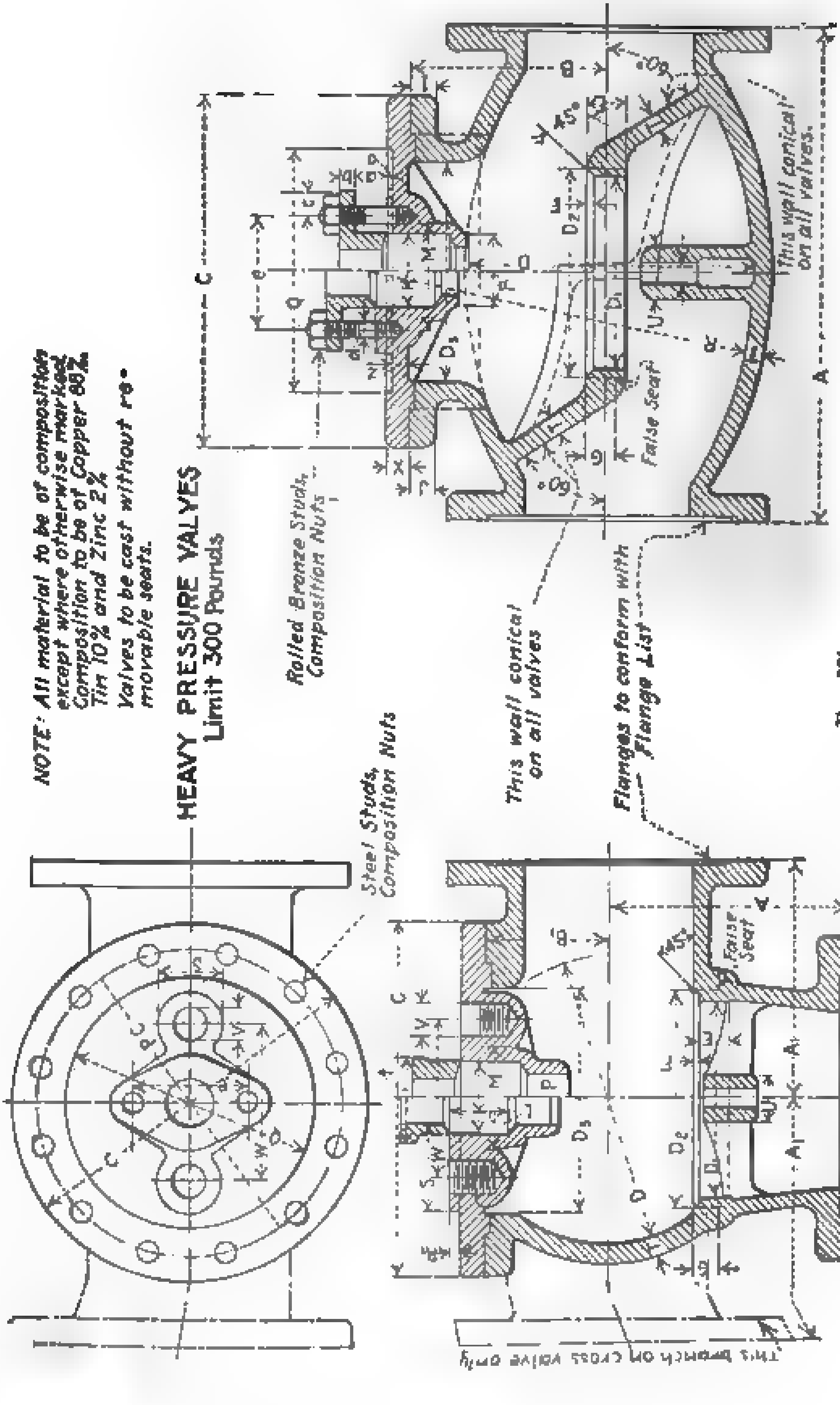

NOTE: All material to be of composition except where otherwise marked. Composition to be of Copper 88% Tin 10% and Zinc 2%
Valves to be cast without removable seats.
HEAVY PRESSURE VALVES
Limit 300 Pounds
Rolled Bronze Studs, Composition Nuts
Steel Studs, Composition Nuts
This wall conical on all valves
Flanges to conform with Flange List
This wall conical on all valves.
False Seat
This branch on cross valve only

Fig. 321.

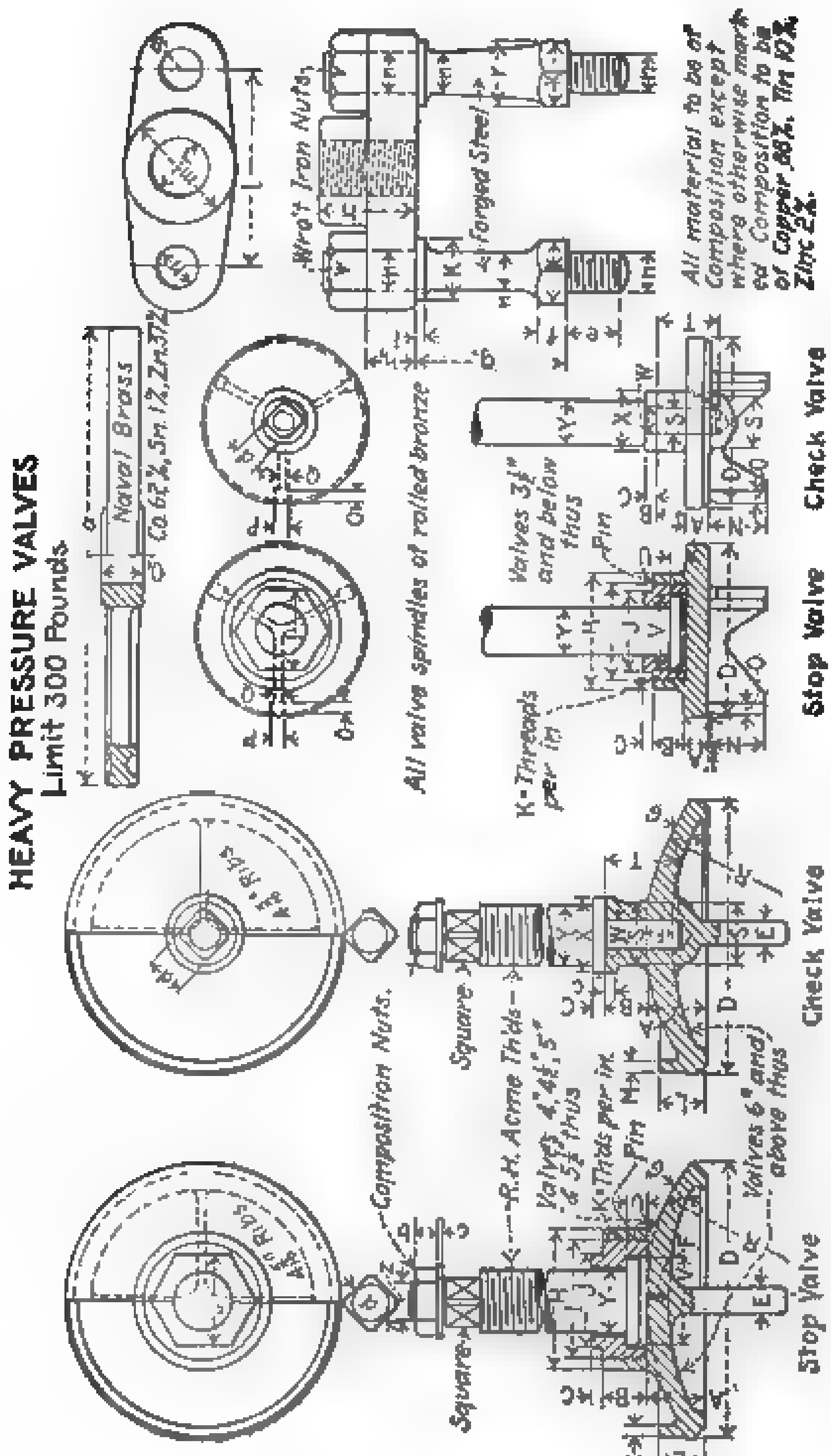

HEAVY PRESSURE VALVES
Limit 300 Pounds
Naval Brass
Cu 62%, Sn 1%, Zn 37%
Wro't Iron Nuts
Forged Steel
All material to be of Composition except where otherwise marked Composition to be of Copper 88%, Tin 10%, Zinc 2%.
All valve spindles of rolled bronze
Valves $3\frac{1}{2}''$ and below thus
K-Threads per in
Pin
Stop Valve
Check Valve
Composition Nuts.
Square
R.H. Acme Thds
Valves 4", $4\frac{1}{2}$", 5" & $5\frac{1}{2}$" thus
K-Thds per in.
Valves 6" and above thus
Stop Valve
Check Valve
Square

FIG. 332

HEAVY PRESSURE

Size of Valve.	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*	*M*	*N*	*O*	*P*	*Q*	*R*	*S*	*T*	*U*
1/2	1/4			1 3/8																	
3/4	1/4			1 7/16																	
1	1/4	1/4	1/4	1 5/8				1 1/2	1 3/8	1 1/16	16			1/4	1/8	3/16	1/8	..	1/2	13/16	1/4
1 1/4	5/16	1/4	1/4	1 3/4				1 3/4	1 1/2	1 1/4	16			3/8	1/8	7/16	1/8	..	3/4	7/8	5/16
1 1/2	5/16	1/4	1/4	2				1 7/8	1 1/2	1 1/2	16			1/2	1/8	5/16	1/8	..	1	15/16	1/4
2	3/8	5/16	1/4	2 1/2				2 1/4	1 3/4	1 7/16	14			1	5/16	1/4	3/16	..	1 1/4	15/16	5/16
2 1/2	7/16	3/8	5/16	3 1/4				2 3/4	2	1 3/4	14			1 1/4	5/16	1/4	3/16	..	1 3/8	1 1/8	3/8
3	1/2	3/8	[illegible]	3 3/4				2 3/4	2 1/4	1	12			1 1/4	3/8	1/4	3/16	..	1 3/8	1 1/4	3/8
3 1/2	9/16	7/16	3/8	4 1/4				2 7/8	2 1/2	2	12			1 1/2	3/8	1/4	3/16	..	1 1/2	1 3/8	7/16
4	1 1/8	1/2	3/8	4 3/4	3/4	5/8	7/16	3 1/4	2 1/2	2	12							4	1 1/2	1 1/2	7/16
4 1/2	1 1/4	1/2	3/8	5 1/4	3/4	5/8	7/16	3 1/2	2 7/8	2 1/4	12							4 1/2	1 1/2	1 1/2	1/2
5	1 1/4	1 & 1 1/4	3/8	5 3/4	3/4	5/8	7/16	3 1/2	3 1/4	2 1/2	12							5	1 1/2	1 11/16	1/2
5 1/2	1 1/4	1 1/4	3/8	[illegible]	7/8	11/16	7/16	4	3 1/2	2 1/2	12							5 1/2	1 1/2	1 3/4	9/16
6	1 1/4	1 1/4	3/8	6 3/4	7/8	11/16	1/2	4 1/4	3 1/2	2 3/4	12	1 1/2	3/4					6	1 1/2	2	5/8
6 1/2	1 1/4	1 1/2	1/2	7 1/4	1	3/4	1/2	4 1/2	3 3/4	2 13/16	12	1 1/2	3/4					6 1/2	1 5/8	2 1/16	5/8
7	1 3/4	1 3/4	1/2	8 1/4	1	3/4	9/16	4 3/4	4	3 1/4	12	1 3/4	3/4					7	1 3/4	2 5/16	11/16
7 1/2	1 7/8	1 1/2	1/2	8 3/4	1	13/16	11/16	4 3/4	4 1/2	3 3/4	10	1 3/4	7/16					7 1/2	1 7/8	2 1/2	3/4
8	2	1 1/2	1/2	9 1/4	1 1/8	13/16	5/8	5 1/4	4 1/2	3 1/4	10	1 3/4	7/16					8	2	2 1/2	13/16
8 1/2	2 1/8	1 5/8	1/2	10	1 1/8	7/8	5/8	5 1/2	4 1/2	3 1/2	10	1 3/4	7/16					8 1/2	2	2 1/2	7/8
9	2 1/2	1 3/4	1/2	10 1/2	1 1/4	7/8	11/16	5 1/2	4 1/2	3 1/2	10	1 1/2	7/16					9	2	2 1/2	7/8
9 1/2	2 1/2	1 3/4	1/2	11	1 1/4	15/16	3/4	5 3/4	4 3/4	3 3/4	10	2	1/2					9 1/2	2 1/4	3	15/16
10	2 5/8	1 7/8	1/2	11 1/2	1 1/4	1	3/4	6 1/4	5 1/4	4 1/4	10	2	1/2					10	2 3/8	3	1
10 1/2	2 1/2	1 7/8	1/2	12	1 1/4	1 1/16	3/4	6 1/2	5 1/4	4 1/4	10	2	1/2					10 1/2	2 3/8	3 1/4	1
11	2 5/8	2	[illegible]	12 1/2	1 1/2	1 1/16	13/16	6 1/2	5 1/2	4 1/2	10	2 1/4	9/16					11	2 1/2	3 1/4	1 1/16
11 1/2	2 5/8	2	1/2	13	1 1/2	1 1/8	13/16	6 7/8	5 3/4	4 5/8	10	2 1/4	9/16					11 1/2	2 3/4	3 1/2	1 1/16
12	2 3/4	2	1/2	13 3/4	1 1/2	1 1/8	7/8	7	5 3/4	5	10	2 1/4	5/8					12	2 3/4	3 1/2	1 1/16
12 1/2	2 7/8	2	1/2	14 1/4	1 1/2	1 1/4	7/8	7 1/4	6	5	10	2 1/4	11/16					12 1/2	2 3/4	3 3/4	1 1/8
13	[illegible]	2 1/4	1/2	14 3/4	1 1/2	1 1/4	15/16	7 1/2	6 1/4	5	10	2 1/2	3/4					13	2 3/4	4	1 1/8
13 1/2	3 1/4	2 1/4	1/2	15 1/4	1 1/2	1 1/4	15/16	7 1/2	6 1/4	5 3/8	10	2 1/2	3/4					13 1/2	2 3/4	4 1/4	1 1/8
14	3 1/4	2 1/2	1/2	16	1 1/2	1 3/8	15/16	8	6 1/2	5 1/2	10	2 1/2	3/4					14	3	4 1/2	1 3/16
14 1/2	3 1/2	2 1/2	1/2	16 1/2	1 1/2	1 3/8	1	8 1/4	6 3/4	5 3/4	10	2 1/2	3/4					14 1/2	3	4 1/2	1 3/16
15	3 3/4	2 1/2	1/2	17	1 1/2	1 1/2	1	8 1/2	7	5 3/4	10	2 1/2	3/4					15	3	4 1/2	1 1/4

VALVES.

V	W	X	Y	Z	a	b	c	d	No Threads on Spindle	e	f	g	h	h_1	i	k	l	m	n	o_1	r	s
			1/4		3				8											7/16		
			3/8		4				7											1/2		
1 1/16	3/8	3/4	5/8	1/4	5	5/16			6											1/2		
1 1/16	3/8	7/8	3/4	5/16	6	5/16			6											9/16		
1 3/16	7/16	1	7/8	3/8	6	3/8			6											9/16		
1 1/4	1/2	1 1/8	1	3/8	7	3/8		5/16	6	3/8	3/8	2 3/8	1 1/4	3/8	1/4	3/8	3	1 1/4	3/8	5/8		11/16
1 3/8	1/2	1 1/4	1	3/8	7	1/2		5/16	5	3/8	1/2	2 11/16	1 1/2	3/8	1/4	3/8	3 1/4	1 1/2	1/2	5/8		11/16
1 1/2	5/8	1 3/8	1 1/8	1/2	8	1/2		7/16	5	7/16	1/2	2 15/16	1 3/4	1/2	5/16	1 1/16	3 1/2	2	1/2	3/4		13/16
1 3/4	5/8	1 1/2	1 1/4	5/8	9	1/2		1/2	4	9/16	1/2	3 1/8	1 7/8	1/2	5/16	1 1/16	3 3/4	2 1/8	5/8	13/16		7/8
2	3/4	1 5/8	1 3/8	5/8	10	1/2		9/16	4	1 1/8	5/16	3 1/4	1 7/8	1	5/16	1 1/8	4 1/4	2 1/4	3/4	1		15/16
2 1/4	3/4	1 3/4	1 1/2	3/4	10	5/8		11/16	4	1 1/4	[illegible]	3 1/2	2 1/8	1 1/8	3/8	1 7/16	4 3/4	2 1/4	1	1		1
2 1/4	7/8	1 7/8	1 5/8	7/8	11	5/8		13/16	4	[illegible]	3/4	3 3/4	2 1/4	1 1/4	3/8	1 5/8	5 1/4	2 3/8	1 1/8	1 1/16		1 1/8
2 1/2	7/8	1 7/8	1 3/4	7/8	12	11/16	25/32	1	4	1 3/8	3/4	3 15/16	2 3/8	1 1/4	3/8	1 5/8	5 1/2	2 5/8	1 1/4	1 1/8		1 1/4
2 3/4	7/8	2	1 7/8	1	12	11/16	25/32	1	4	1 5/16	3/4	4 1/16	2 5/8	1 3/8	3/8	1 3/4	5 3/4	3	1 3/8	1 1/4		1 3/8
2 3/4	1	2 1/8	1 7/8	1	14	7/8	27/32	1 1/16	4	1 5/16	3/4	4 5/16	2 7/8	1 3/8	7/16	1 3/4	5 3/4	3 1/4	1 1/2	1 5/16		1 1/2
2 7/8	1	2 1/4	2	1	14	7/8	29/32	1 1/8	4	1 5/8	7/8	4 7/16	3	1 1/2	7/16	2	6 1/4	3 1/2	1 5/8	1 5/16		1 5/8
3 1/4	1	2 3/8	2 1/8	1 1/8	14	1	31/32	1 1/4	4	1 13/16	1	4 3/4	3 1/4	1 5/8	7/16	2 1/16	6 3/4	3 3/4	1 3/4	1 7/16		1 7/16
3 1/2	1 1/8	2 1/2	2 1/4	1 1/8	16	1	31/32	1 3/8	4	1 15/16	1	5	3 1/2	[illegible]	7/16	2 3/16	7 1/4	4	1 7/8	1 7/16		1 9/16
3 3/4	1 1/4	2 5/8	2 3/8	1 1/4	16	1 1/16	31/32	1 1/2	4	2 1/16	1	5 1/4	3 3/4	1 3/4	9/16	2 1/4	7 1/2	4 1/4	1 7/8	1 7/16		1 5/8
3 3/4	1 1/4	2 3/4	2 1/2	1 1/4	16	1 1/8	31/32	1 5/8	4	2 3/16	1 1/8	5 1/2	3 3/4	1 3/4	1/2	2 5/16	7 3/4	4 1/2	2	1 7/16		1 11/16
3 7/8	1 3/8	2 7/8	2 5/8	1 3/8	18	1	31/32	1 3/4	4	2 5/16	1 1/4	5 3/4	4	1 7/8	1/2	2 5/16	8 1/4	4 3/4	2 1/8	1 5/8		1 13/16
3 7/8	1 1/2	3	2 3/4	1 1/2	18	1	31/32	1 7/8	4	2 1/2	1 1/2	5 7/8	4	2	1/2	2 1/2	9	4 7/8	2 1/4	1 3/4	2 1/4	1 7/8
4	1 5/8	3	2 7/8	1 1/2	18	1 1/8	1 1/32	1 7/8	4	2 5/8	1 5/8	6	4 1/4	2 1/4	1/2	2 13/16	9	5	2	1 7/8	2 1/2	1 15/16
4 1/4	1 5/8	3 1/4	2 7/8	1 5/8	21	1 3/16	1 1/32	1 7/8	4	2 3/4	1 3/4	6 1/4	4 1/2	2 1/4	1/2	2 15/16	9 1/2	5 1/4	2	1 7/8	2 1/2	1 15/16
4 1/2	1 3/4	3 1/2	3	1 3/4	21	1	1 1/32	2	4	2 13/16	1 3/4	6 1/2	4 5/8	2 1/2	5/8	3 1/4	10	5 1/2	2 1/4	1 7/8	2 5/8	2 1/8
4 1/2	1 3/4	3 5/8	3 1/4	1 7/8	21	1	1 1/32	2	4	2 15/16	1 7/8	6 3/4	4 3/4	2 1/2	5/8	3 1/4	10	5 3/4	2 1/2	1 7/8	2 3/4	2 1/4
4 5/8	1 3/4	3 3/4	3 1/2	1 7/8	21	1	1 1/32	2	4	2 15/16	1 7/8	6 7/8	4 7/8	2 5/8	5/8	3 1/2	10 1/2	6	2 1/2	1 7/8	2 7/8	2 3/8
4 3/4	1 3/4	3 7/8	3 1/2	1 7/8	21	1	1 1/32	2	4	3 1/8	1 3/4	7 1/4	5	2 3/4	3/4	3 1/2	11	6	2 3/4	1 7/8	3	2 3/8
4 3/4	1 3/4	3 7/8	3 3/4	2	24	1 1/4	1 1/32	2 1/4	4	3 1/4	1 7/8	7 1/2	5 1/4	2 3/4	3/4	3 1/2	11 1/4	6 1/4	2 3/4	2 1/16	3	2 1/2
4 7/8	1 7/8	3 7/8	3 7/8	2	24	1 1/4	1 1/32	2 1/4	4	3 1/4	1 7/8	7 3/4	5 1/2	2 7/8	3/4	3 3/4	11 3/4	6 1/2	2 7/8	2 1/16	3	2 5/8
5	1 7/8	3 7/8	3 7/8	2	24	1 1/4	1 1/32	2 1/4	4	3 1/2	2	7 7/8	5 1/2	3	1	3 7/8	12 1/2	6 3/4	2 7/8	2 1/16	3 1/4	2 3/4
5 1/4	1 7/8	4 1/4	3 7/8	2	24	1 1/4	1 1/32	2 1/4	4	3 1/2	2	8	5 5/8	3	1	3 7/8	13	7 1/4	2 7/8	2 1/16	3 1/2	2 7/8

FRICTION BRAKE FOR CRANES.

The crane brake is solely for the purpose of preventing the load from falling when there is no other sustaining force and preventing the load from falling faster than desired when lowering. Incorrect disposition of the friction of a brake in relation to the load and power makes its purpose unattainable, and an improper proportion of friction to load makes its operation doubtful and unsatisfactory, causing it to either slip or stall the motor when trying to lower. The general features of brake friction brakes are as follows: A cam in some part of the transmission mechanism is so designed that the downward pressure of the load causes an axial pull in the shaft which presses friction

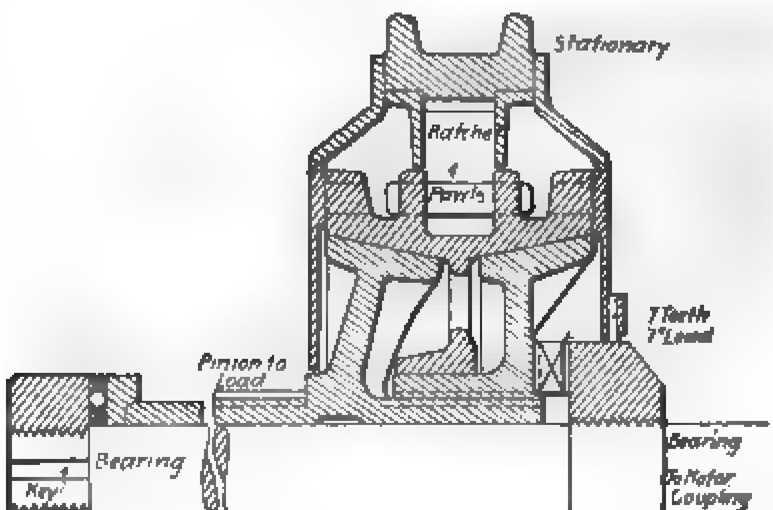


FIG. 323.—Cone Brake "Naval" Boat Crane Full Load Torque = 7880 In-Lbs.

surfaces together. The outer casing or barrel is allowed to rotate with the other parts when hoisting, but prevented from rotating when lowering by ratchet and pawls or band brake. Lowering, then, is always accompanied by relative motion between the friction discs or cones and whatever friction is developed between these tends to prevent the load from lowering and must necessarily be overcome or relieved. The proper arrangement of friction brakes is obtained by dividing the friction between the power and load ends of brake, half being on the motor side and half on the load side of the cam. Examples of this type are shown in the cone brake for a gantry crane and in the Seller's type of disc friction brake supplied for naval boat cranes. The reasons for this arrangement will be developed in the following discussion.

Case I. — Two friction brakes designed with all the friction on the load side of cam as shown on accompanying sketches, Figs. 323 and 325, one taken from the automatic brake for boat crane of battleship and the other being the brake supplied by the builders of the gantry crane. This arrangement of friction is entirely erroneous, as the motor must always keep some force on the cam to prevent the friction surfaces from separating, and allowing the load to slip. Suppose AO, Fig. 324, to represent the force required to overcome the load, applied at mean radius on the cam, OB represents the axis of the shaft. If in a given design we assume that an axial pull of OC is required to cause sufficient friction to overcome the load, GG will represent the slope of a cam which will just supply the requisite pull. OD is its normal pressure, and $AD = OC$ is the axial component. With cam GG the friction of the brake just balances the load supported by AO.

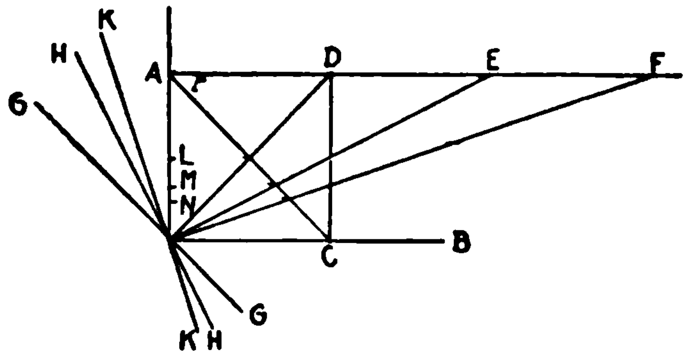


Fig. 324.

When this brake is lowering and the motor withdraws its pressure against the cam, the load will drop until it overtakes the power side of the cam and causes a normal pressure with an axial component sufficient to again set up the frictions. This same normal pressure always tends to drive the motor downward and it will thus be seen that even when the load is being lowered the motor must exercise a force against the cam in the direction tending to lift the load. Thus, with the above cam GG and axial component OC, we find by drawing the balance diagonal AC, that in lowering at constant speed, one-half of the load is overcome by the friction of the brake, see AL, and the other half has to be overcome by an upward pressure of the motor, see OL. Suppose we represent by R the ratio of the axial pull in the shaft due to hoisting full load to the axial pull required to just balance the load. In the case above, $R = 1$. Suppose $R = 2$, the axial component being $AE = 2\,OC$, we find that when lowering at constant speed the friction of the brake overcomes $AM = \frac{2}{3}$ of the load, and the motor has to supply $OM = \frac{1}{3}$ of the load in the direction tending to lift the load. Again, if $R = 3$, the axial component $= AF = 3\,OC$, and the motor lowers with $\frac{1}{4}$ load supported by the motor, ON, and $\frac{3}{4}$ load supported by the friction of the brake, AN. Thus, if $R = n$, the lowering will take place with $\frac{n}{n+1}$ of the load overcome by friction in the brake and $\frac{1}{n+1}$ supported

by a raising pressure on the motor side of the cam. In a brake with all of the friction on the load side of the cam it is obviously impossible to check the tendency of the load to drop without maintaining an upward pressure on the motor side of the cam so as to keep the friction set. The main object of an automatic brake is therefore impossible to obtain with this arrangement, and the motor is run backward against the force which it has to apply on the cam in order to keep the friction surfaces operative. The best that can be done with this arrangement is to make the value of R as large as possible, by using say 8 to 10 degrees angle of cones and as small a lead of cam as the shaft will stand, thereby reducing the value $\frac{1}{n+1}$ to be supported by the motor. A magnetic clutch on the motor, or great friction of bearings is necessary to hold the cam in such an arrangement when power is cut off from motor.

Calculation of Cone Brake for Gantry Crane.

The full-load force on $25\frac{1}{3}$-inch pitch diameter gear is 2400 pounds. The torque then is $2400 \times \frac{25\frac{1}{3}}{2} = 30,400$ inch-pounds.

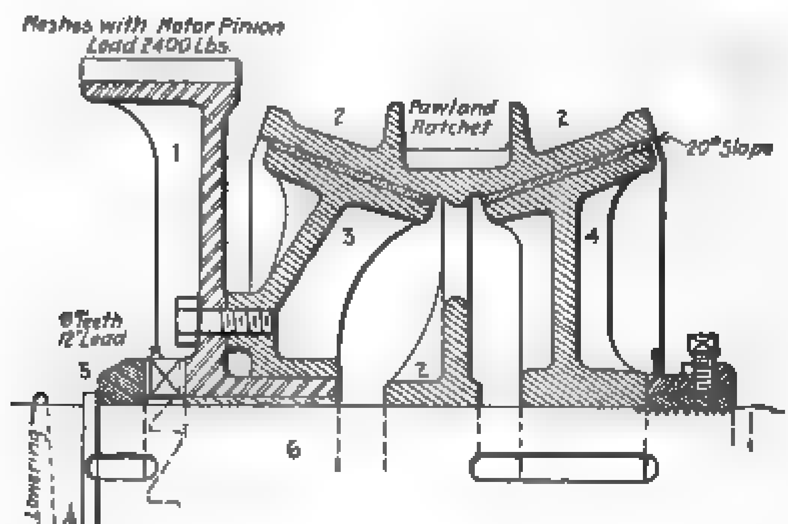


FIG. 325.—Cone Brake for Gantry Crane Full Load Torque = 30,400 In-Lbs.

Taking the mean radius of the brake cones as $9\frac{1}{2}$ inches, the force of friction required at this radius is $\frac{30,400}{9.5} = 3200$ pounds. Then if we assume a coefficient of friction of 0.1 between the friction surfaces, the normal pressure required on the cones will

be 32,000 pounds. This has to be obtained by a suitable angle of cam in combination with the slope of the friction cones. Taking the mean radius of the cam as 3 inches we get $\frac{30,400}{3} = 10,133$ pounds tangential pressure.

Referring to diagram, Fig. 327, OB represents the axis of brake shaft. Laying down this cam pressure to the scale of 10,000 pounds = 1 inch we obtain OA normal to OB. If we use 12-inch pitch for the cam its slope is represented by CD, and we find from the normal OE that the axial pull will be ON, friction not considered. Allowing for 0.15 coefficient of friction on the cam we lay off FOE an angle whose tangent is 0.15 and obtain OM as the axial pull. Extend MF and intersect same by OG the required normal pressure 32,000 pounds to scale. Perpendicular

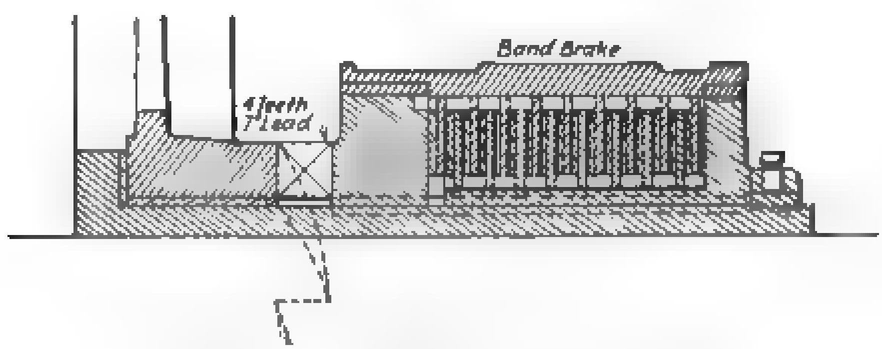


FIG. 326.—Original Disc Brake on Gantry Crane.

to this we get the slope of the cones OH, which will obtain the above normal pressure with the given axial pull. By measurement BOH is found to be 21¼ degrees. If we use a cone angle of 20 degrees and return through the construction from H-G-F-E-CD we find that the necessary axial pull will be given by a cam whose lead is 12¾ inches. The use of 12-inch lead on cam with 20-degree cones will, therefore, furnish a friction slightly in excess of that required under the conditions mentioned. Probably the friction between the cones will never reach a lower coefficient than the 0.1 assumed, but in case this should occur the first motion will produce vibration destroying the friction on the cam surface and produce additional axial pull approaching ON. The construction of point K shows that brake will operate on a coefficient of 0.08 or less when cam friction is destroyed.

The width of the cones is determined by the pressure desired. Using 50 pounds per square inch we need $\frac{32,000}{50} = 640$ square inches area and $\frac{640}{9.5 \times 2\pi} = 10\frac{3}{4}$ inches width, say $5\frac{1}{2}$ inches width of each cone.

The oiling system is designed to pick up oil outside of cones and deposit same between cones when lowering, so that the oil must pass continually from small to large ends of both cones.

There are, as seen by the above, and by reference to Fig. 324, three quantities inter-related in brakes of the class just designed for the gantry crane. The normal pressure required on the friction surfaces, the angle of the cones, and, the lead of the cam.

With given materials the pressure per square inch can be decided upon and the diameter and breadth of cones chosen to take the total pressure which is the frictional torque needed divided by the mean radius of cones and by the coefficient of friction. This quantity arranged, we can assume a value for one of the other variables and determine the remaining quantity, a couple of trials being needed to obtain a suitable set of values.

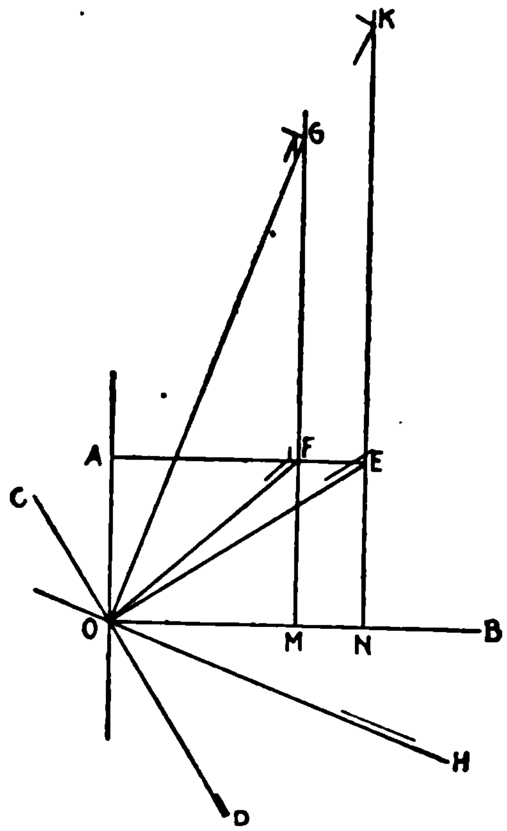


Fig. 327.

If, instead of 50 pounds per square inch, we had used materials allowing 200 pounds per square inch as in Fig. 324, the brake, Fig. 327, could have been much smaller, and a design with 6-inch mean radius of cones would have 15-degree cones each $3\frac{3}{8}$ inches wide with a 10-inch lead on cam of 3-inch radius.

The axial pull is least affected by friction on the cam when the lead is such as to give a cam angle of about 40 degrees, and angles between 25 and 40 degrees are therefore preferable. Lubrication of the cam should be arranged or the operator instructed to keep cam well greased. Pawls should be designed carefully, as light as possible and nearly balanced, and their friction levers should be long enough to positively operate the pawls. Wood friction pieces slip when wet and metal pieces when oily so corks are used since they have 0.30 to 0.36 coefficient of friction under varying conditions and, with relatively smaller pressure, have 3 to 6 times the life of wood for friction blocks.

Case II. — Taking the second case, where all of the friction is gathered on the motor side of the cam, we get a brake the reverse of the above arrangement in which all of the purposes are *obtainable* but liable to be unsatisfactory if for any reason,

such as lack of attention to lubrication, the coefficients of friction on the working surfaces should vary greatly from those expected. Let OA, Fig. 324, again represent the lifting force of the motor on the cam, GG the slope of the cam and OC the axial component required to just balance the load. If all power be turned off the motor or even if the motor pinion or couplings be removed, the lowering tendency of the load will cause the normal pressure OD whose axial component OC locks the frictions and prevents dropping. Now suppose this brake to be designed for 0.1 coefficient of friction, the friction on the cam not being considered. If for some reason this coefficient of friction should drop to 0.08 or the friction between the sliding

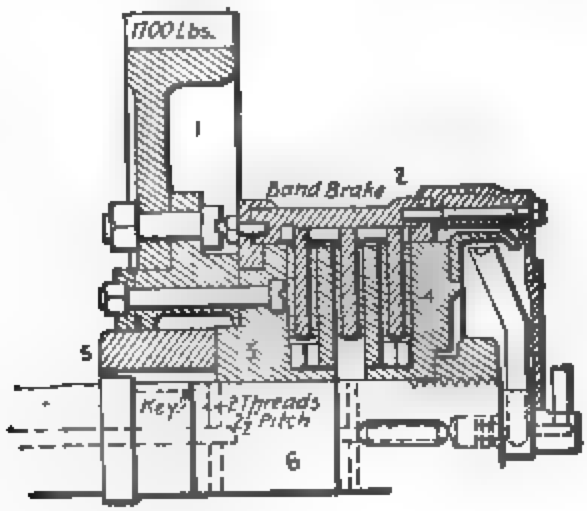


Fig. 328. — Sellers Type Disc Friction Brake for Boat Crane
Full Load Torque = 21,900 In. Lbs.

surfaces of the cam should become apparent, this normal pressure OD will be insufficient to lock the load. We must then design for the worst conditions allowing, say, 0.15 coefficient of friction on the cam. If this brake were allowed to run dry and the coefficient of friction between the working surfaces rose to, say 0.15, and the friction between the cam surfaces was overcome by the vibration of the machinery, then the pressure of the load on the cam would cause an axial component supplying more than twice the necessary friction, and the motor to lower must exert more than its normal power, *i.e.*, run overloaded to force the load down.

Case III. — This state of affairs can be overcome by the arrangement of brakes shown in Figs. 325 and 328, in which the friction is divided between the motor and load ends. In these

brakes the cones or discs will have the same total area as in the foregoing case, but with a marked difference in operation. Take the case when $R = 1$, the axial component OC, Fig. 324, will cause just enough friction to balance the load when starting to lower. The motor must overcome the difference between the resistance of the friction on its side of the cam and the turning effect of the load pressure against the cam. As soon as this is overcome the pressure betweeen the cam surfaces drops to $\frac{1}{2}$ of its hoisting value, that is, $\frac{1}{2}$ of load AL will be overcome by friction on load side and other half OL by friction on the motor side, so that in lowering this brake the motor must give downward direction, but no power is required to lower unless R exceeds 1. This brake must be designed also for minimum conditions expected, say coefficient of friction = 0.1 on sliding surfaces and = 0.15 on cam surfaces. It locks to an equal extent as the brake just discussed with friction entirely on the power side of cam, but instead of using full power or overload on the motor when lowering under adverse conditions, on this brake it would only require a large force to overcome the first frictional set of the brake when starting to lower and would lower thereafter with never more than one-half of the motor's normal load, as can be seen by the discussion of Fig. 324. Even if this brake were designed well on the safe side, say $R = 1\frac{1}{4}$, to provide a margin when locking the load and should double its coefficient of friction the force of $1\frac{1}{2}$ normal load which would stall the motor in Case II could be easily furnished for the instant necessary in starting by a series wound motor, and the brake thereafter would lower easily with some small downward force exerted by the motor. This last arrangement with frictions divided between motor and load ends, in addition to being effectively self-locking and unapt to stall, has the further advantage of being the least complicated of all cases as can be seen by comparison of Figs. 325 and 328.

VENTILATION.

The accompanying sketch shows a complete system of ventilation designed and calculated according to results of experiments relative to deliveries of ventilation systems on board ship made by D. W. Taylor, Naval Constructor, U. S. N., at the Experimental Model Basin, Navy Yard, Washington, D. C.

The first point to be determined in laying out any system of ship ventilation is the amount of air that is required in each compartment to be ventilated, assuming that the number of cubic feet of air to be delivered per minute as marked on sketch at each terminal is the amount required at that special point for the efficient ventilation of any compartment or com-

VENTILATION SYSTEM.

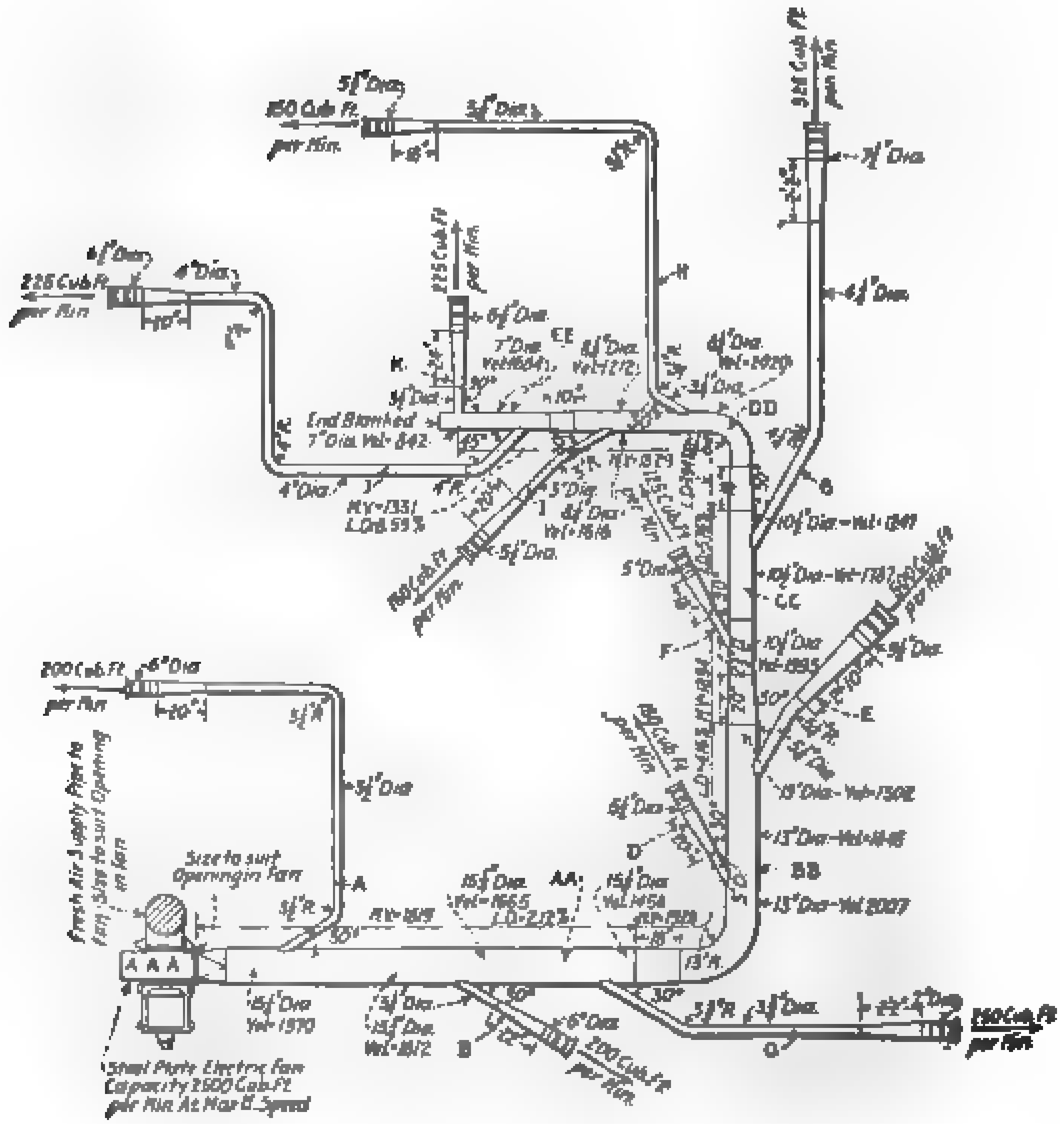


FIG. 329.

partments, such as engine rooms, water closets, cabin spaces, storerooms, magazines, etc.; the fan is then placed in the most convenient location for economy in piping. The next step is the head of the main or mains which should be as straight as possible with the number of bends reduced to a minimum. Then make the standard conditions at the first outlet 5 pounds pressure, and about 2000 feet per minute velocity. "This pressure of 5 pounds per square foot is for standard conditions of air, density corresponding to a barometric height of 30 inches, a temperature of 70 degrees Fahrenheit and a relative humidity of 70 per cent. Under these standard conditions a cubic foot of air weighs 0.07465 pound. The pressure of 5 pounds is equivalent to a pressure head of 67 feet of standard density air. A velocity of 2000 feet per minute corresponds to a velocity head of 17.27 feet. The total head then against which air is delivered to the supply main is 84.27 feet."

As the branches lead off do not change the size of the main until sufficient air has been removed to reduce the velocity to a value between 1200 and 1500 feet per minute. Then contract the mains with a taper of 1½ inches to the foot until the area is so reduced that the velocity again becomes about 2000 feet per minute. Repeat the contraction wherever necessary, but do not reduce the final diameter of the main to less than twice the diameter of the last branch.

A 15¼-inch diameter pipe is selected for the first section of the main, on account of giving the nearest velocity to 2000 feet per minute. After branches *A*, *B*, and *C* have been taken off the velocity is reduced to 1458 feet per minute. Being below 1500 feet per minute the main is reduced in size with a taper of 1½ inches to the foot to 13-inch diameter which increases the velocity to 2007 feet per minute. At the beginning of the 13-inch diameter or B.B. section of the main, the direction is changed 90 degrees which should be done with an elbow having a radius of throat not less than diameter of pipe. When branches *D* and *E* have been taken off the velocity becomes 1302 feet per minute; the main is again reduced in size with a taper 1½ inches to the foot to 10½-inch diameter increasing the velocity to 1995, and again branches *F* and *G* reduce the velocity to 1247 feet per minute, which necessitates changing the size of the main to 8¼-inch diameter, bringing the velocity up to 2020 feet per minute. Branches *H* and *I* again reduce it to 1212 feet per minute as the main should never be reduced to less than twice the diameter of the last branch but it can now only be reduced to about 7-inch diameter to be settled definitely later when sizes of branches are determined.

CHART FOR VENTILATION PIPES.

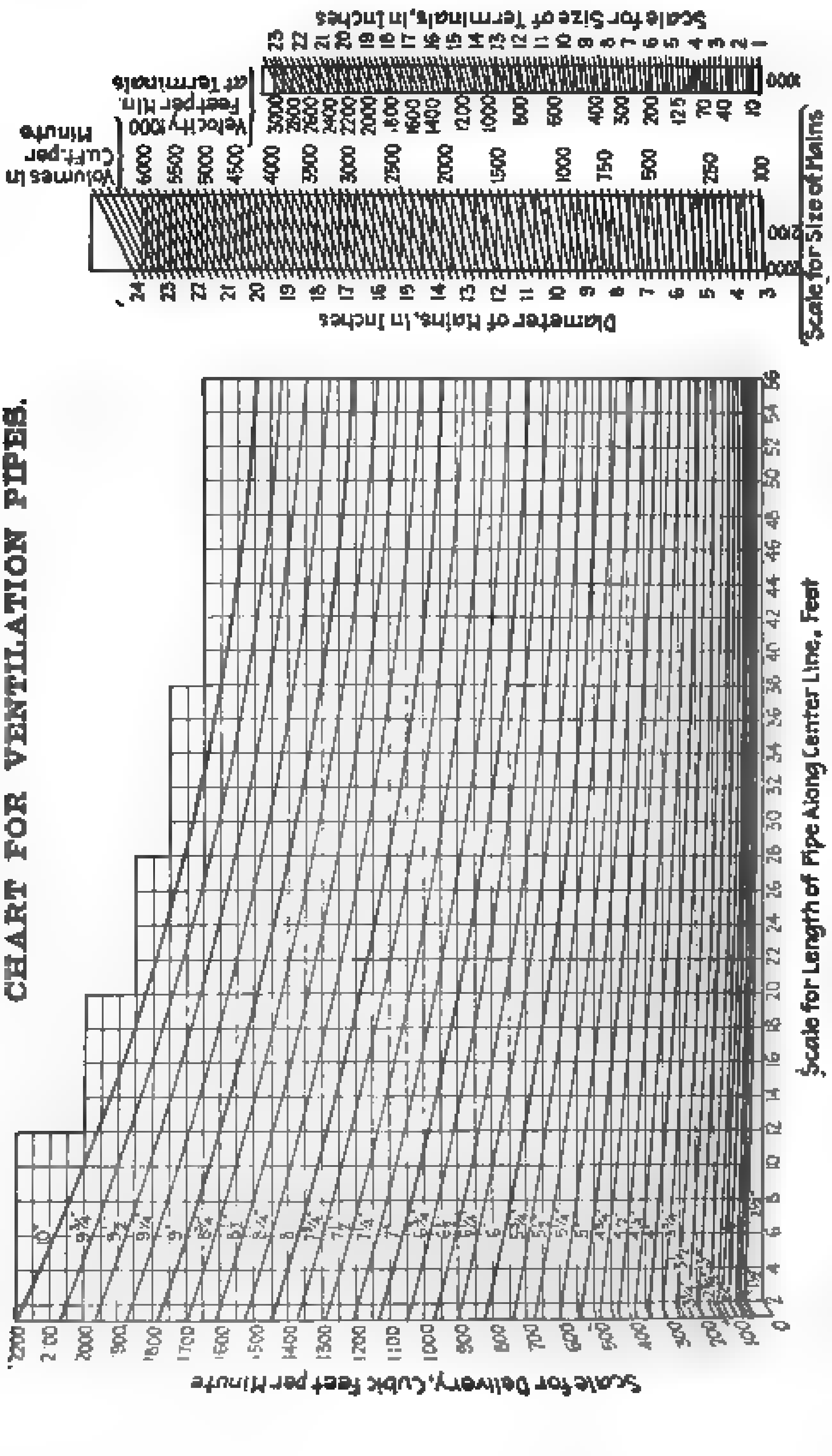


Fig. 330.

FRICTION BRAKE FOR CRANES.

The crane brake is solely for the purpose of preventing the load from falling when there is no other sustaining force and preventing the load from falling faster than desired when lowering. Incorrect disposition of the friction of a brake in relation to the load and power makes its purpose unattainable, and an improper proportion of friction to load makes its operation doubtful and unsatisfactory, causing it to either slip or stall the motor when trying to lower. The general features of brake friction brakes are as follows: A cam in some part of the transmission mechanism is so designed that the downward pressure of the load causes an axial pull in the shaft which presses friction

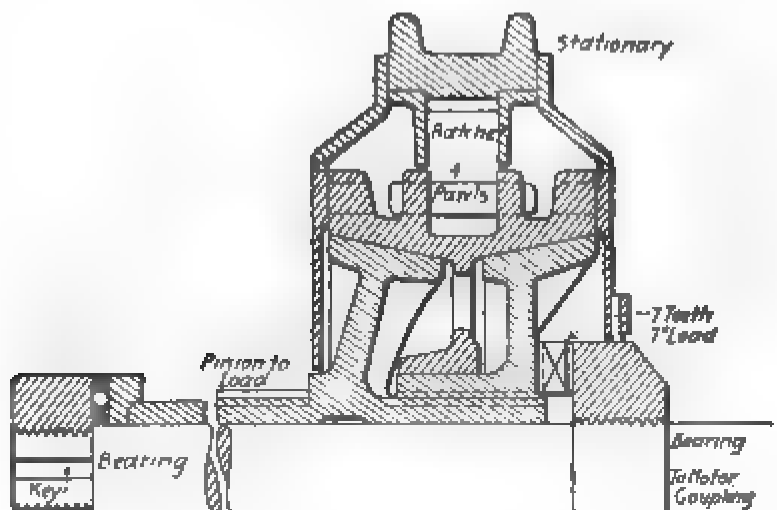


Fig. 323.—Cone Brake "Naval" Boat Crane Full Load Torque = 7880 In-Lbs.

surfaces together. The outer casing or barrel is allowed to rotate with the other parts when hoisting, but prevented from rotating when lowering by ratchet and pawls or band brake. Lowering, then, is always accompanied by relative motion between the friction discs or cones and whatever friction is developed between these tends to prevent the load from lowering and must necessarily be overcome or relieved The proper arrangement of friction brakes is obtained by dividing the friction between the power and load ends of brake, half being on the motor side and half on the load side of the cam Examples of this type are shown in the cone brake for a gantry crane and in the Seller's type of disc friction brake supplied for naval boat cranes. The reasons for this arrangement will be developed in the following discussion.

Case I. — Two friction brakes designed with all the friction on the load side of cam as shown on accompanying sketches, Figs. 323 and 325, one taken from the automatic brake for boat crane of battleship and the other being the brake supplied by the builders of the gantry crane. This arrangement of friction is entirely erroneous, as the motor must always keep some force on the cam to prevent the friction surfaces from separating, and allowing the load to slip. Suppose AO, Fig. 324, to represent the force required to overcome the load, applied at mean radius on the cam, OB represents the axis of the shaft. If in a given design we assume that an axial pull of OC is required to cause sufficient friction to overcome the load, GG will represent the slope of a cam which will just supply the requisite pull. OD is its normal pressure, and $AD = OC$ is the axial component. With cam GG the friction of the brake just balances the load supported by AO.

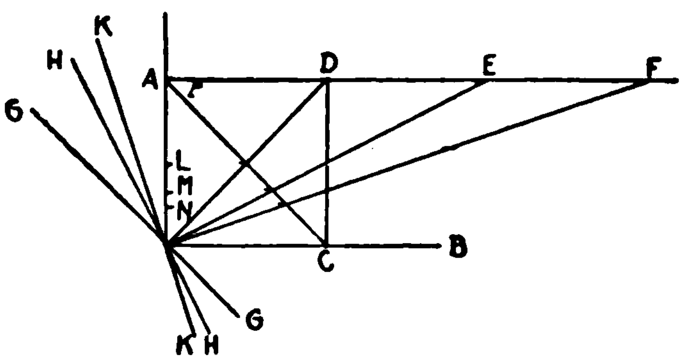


FIG. 324.

When this brake is lowering and the motor withdraws its pressure against the cam, the load will drop until it overtakes the power side of the cam and causes a normal pressure with an axial component sufficient to again set up the frictions. This same normal pressure always tends to drive the motor downward and it will thus be seen that even when the load is being lowered the motor must exercise a force against the cam in the direction tending to lift the load. Thus, with the above cam GG and axial component OC, we find by drawing the balance diagonal AC, that in lowering at constant speed, one-half of the load is overcome by the friction of the brake, see AL, and the other half has to be overcome by an upward pressure of the motor, see OL. Suppose we represent by R the ratio of the axial pull in the shaft due to hoisting full load to the axial pull required to just balance the load. In the case above, $R = 1$. Suppose $R = 2$, the axial component being $AE = 2\,OC$, we find that when lowering at constant speed the friction of the brake overcomes $AM = \frac{2}{3}$ of the load, and the motor has to supply $OM = \frac{1}{3}$ of the load in the direction tending to lift the load. Again, if $R = 3$, the axial component $= AF = 3\,OC$, and the motor lowers with $\frac{1}{4}$ load supported by the motor, ON, and $\frac{3}{4}$ load supported by the friction of the brake, AN. Thus, if $R = n$, the lowering will take place with $\frac{n}{n+1}$ of the load overcome by friction in the brake and $\frac{1}{n+1}$ supported

by a raising pressure on the motor side of the cam. In a brake with all of the friction on the load side of the cam it is obviously impossible to check the tendency of the load to drop without maintaining an upward pressure on the motor side of the cam so as to keep the friction set. The main object of an automatic brake is therefore impossible to obtain with this arrangement, and the motor is run backward against the force which it has to apply on the cam in order to keep the friction surfaces operative. The best that can be done with this arrangement is to make the value of R as large as possible, by using say 8 to 10 degrees angle of cones and as small a lead of cam as the shaft will stand, thereby reducing the value $\frac{1}{n+1}$ to be supported by the motor. A magnetic clutch on the motor, or great friction of bearings is necessary to hold the cam in such an arrangement when power is cut off from motor.

Calculation of Cone Brake for Gantry Crane.

The full-load force on $25\frac{1}{3}$-inch pitch diameter gear is 2400 pounds. The torque then is $2400 \times \frac{25\frac{1}{3}}{2} = 30{,}400$ inch-pounds.

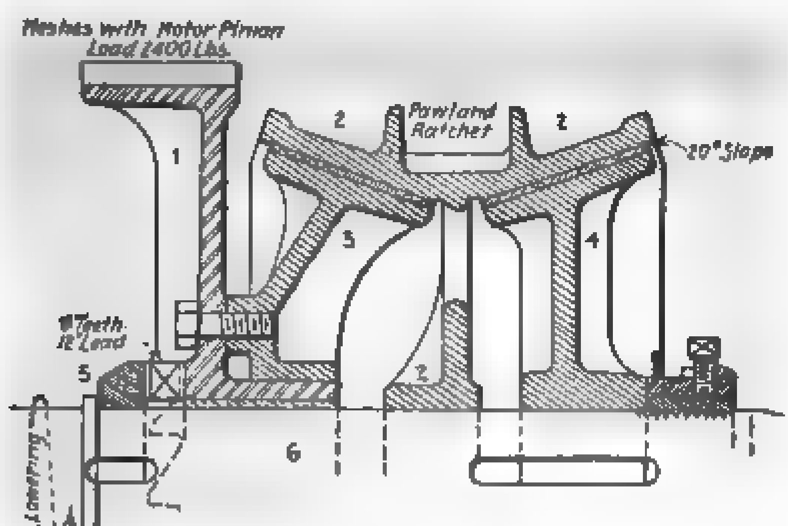


FIG. 325.—Cone Brake for Gantry Crane Full Load Torque = 30,400 In-Lbs.

Taking the mean radius of the brake cones as $9\frac{1}{2}$ inches, the force of friction required at this radius is $\frac{30{,}400}{9.5} = 3200$ pounds. Then if we assume a coefficient of friction of 0.1 between the friction surfaces, the normal pressure required on the cones will

be 32,000 pounds. This has to be obtained by a suitable angle of cam in combination with the slope of the friction cones. Taking the mean radius of the cam as 3 inches we get $\frac{30,400}{3} = 10,133$ pounds tangential pressure.

Referring to diagram, Fig. 327, OB represents the axis of brake shaft. Laying down this cam pressure to the scale of 10,000 pounds = 1 inch we obtain OA normal to OB. If we use 12-inch pitch for the cam its slope is represented by CD, and we find from the normal OE that the axial pull will be ON, friction not considered. Allowing for 0.15 coefficient of friction on the cam we lay off FOE an angle whose tangent is 0.15 and obtain OM as the axial pull. Extend MF and intersect same by OG the required normal pressure 32,000 pounds to scale. Perpendicular

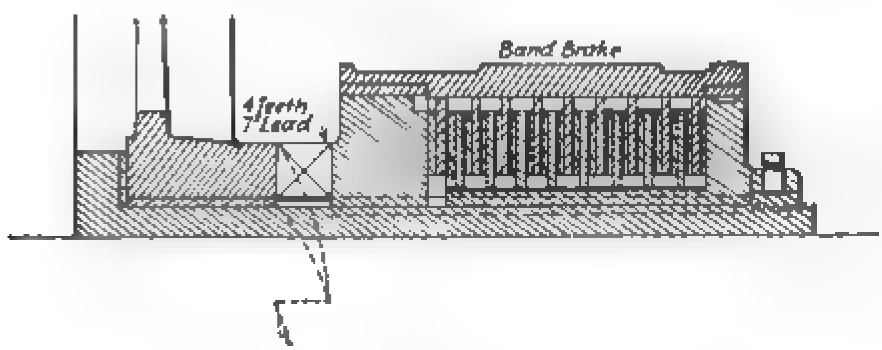


Fig. 326.—Original Disc Brake on Gantry Crane.

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The width of the cones is determined by the pressure desired. Using 50 pounds per square inch we need $\frac{32,000}{50} = 640$ square inches area and $\frac{640}{9.5 \times 2\pi} = 10\frac{3}{4}$ inches width, say $5\frac{3}{8}$ inches width of each cone.

The oiling system is designed to pick up oil outside of cones and deposit same between cones when lowering, so that the oil must pass continually from small to large ends of both cones.

There are, as seen by the above, and by reference to Fig. 324, three quantities inter-related in brakes of the class just designed for the gantry crane. The normal pressure required on the friction surfaces, the angle of the cones, and, the lead of the cam.

With given materials the pressure per square inch can be decided upon and the diameter and breadth of cones chosen to take the total pressure which is the frictional torque needed divided by the mean radius of cones and by the coefficient of friction. This quantity arranged, we can assume a value for one of the other variables and determine the remaining quantity, a couple of trials being needed to obtain a suitable set of values.

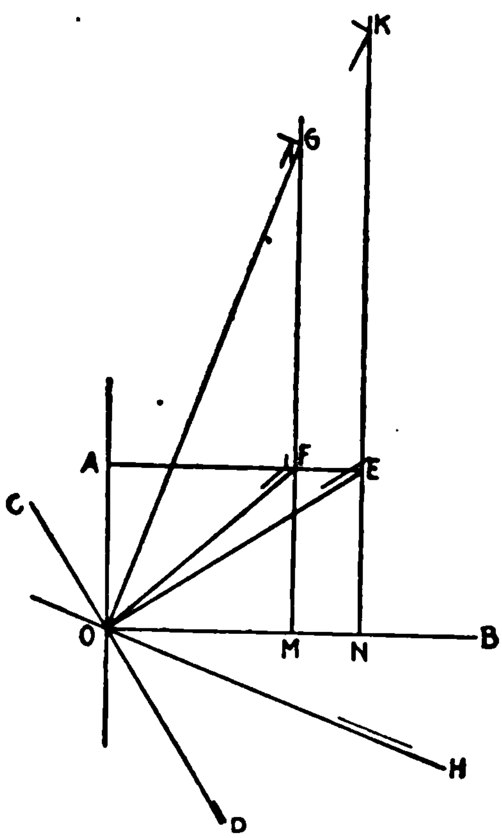

FIG. 327.

If, instead of 50 pounds per square inch, we had used materials allowing 200 pounds per square inch as in Fig. 324, the brake, Fig. 327, could have been much smaller, and a design with 6-inch mean radius of cones would have 15-degree cones each $3\frac{3}{8}$ inches wide with a 10-inch lead on cam of 3-inch radius.

The axial pull is least affected by friction on the cam when the lead is such as to give a cam angle of about 40 degrees, and angles between 25 and 40 degrees are therefore preferable. Lubrication of the cam should be arranged or the operator instructed to keep cam well greased. Pawls should be designed carefully, as light as possible and nearly balanced, and their friction levers should be long enough to positively operate the pawls. Wood friction pieces slip when wet and metal pieces when oily so corks are used since they have 0.30 to 0.36 coefficient of friction under varying conditions and, with relatively smaller pressure, have 3 to 6 times the life of wood for friction blocks.

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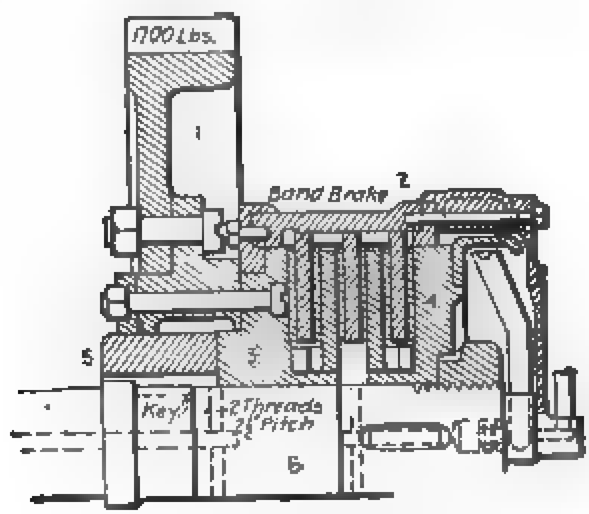

FIG. 328. — Sellers Type Disc Friction Brake for Boat Crane
Full Load Torque = 21,900 In. Lbs.

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VENTILATION.

The accompanying sketch shows a complete system of ventilation designed and calculated according to results of experiments relative to deliveries of ventilation systems on board ship made by D. W. Taylor, Naval Constructor, U. S. N., at the Experimental Model Basin, Navy Yard, Washington, D. C.

The first point to be determined in laying out any system of ship ventilation is the amount of air that is required in each compartment to be ventilated, assuming that the number of cubic feet of air to be delivered per minute as marked on sketch at each terminal is the amount required at that special point for the efficient ventilation of any compartment or com-

VENTILATION SYSTEM.

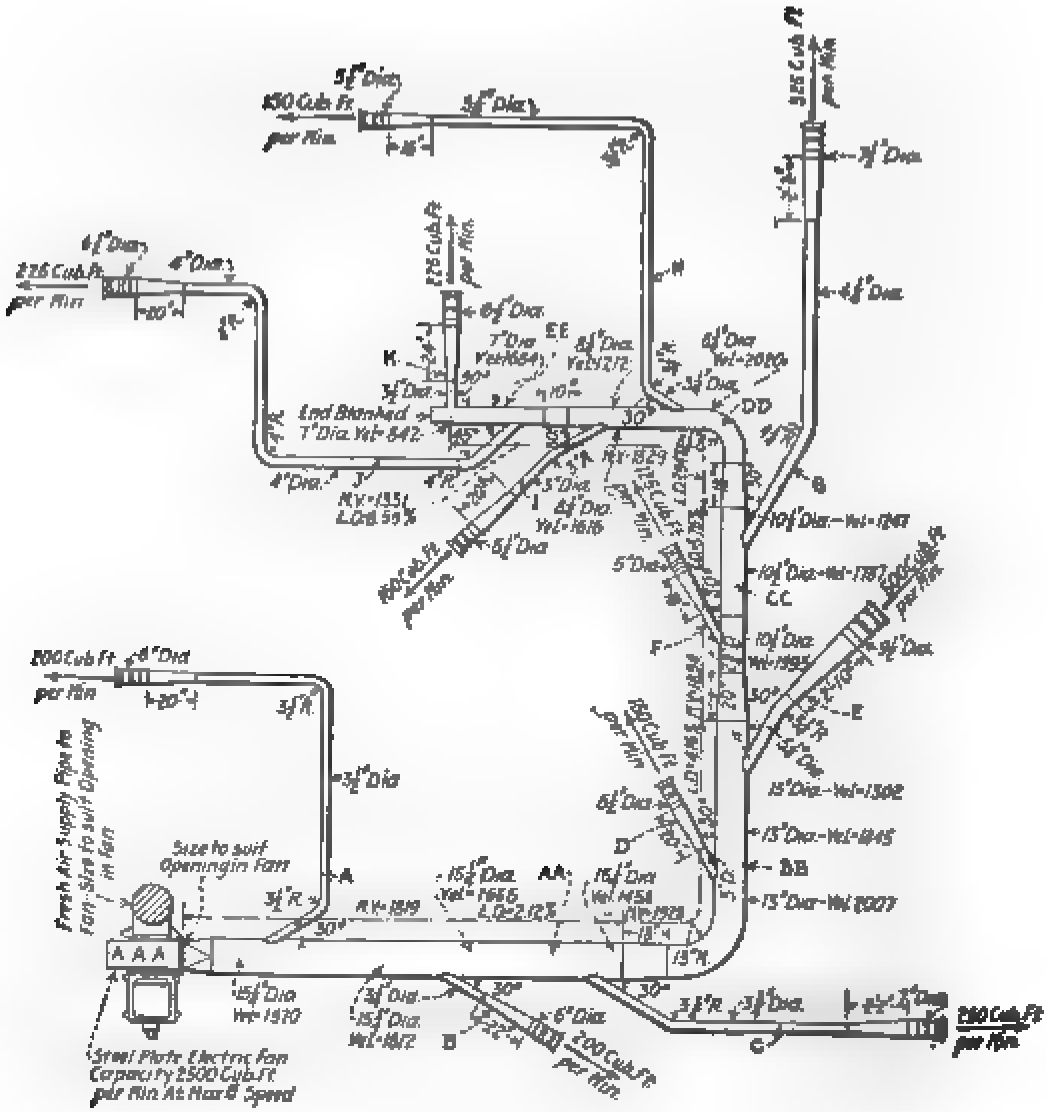


FIG. 329.

partments, such as engine rooms, water closets, cabin spaces, storerooms, magazines, etc.; the fan is then placed in the most convenient location for economy in piping. The next step is the head of the main or mains which should be as straight as possible with the number of bends reduced to a minimum. Then make the standard conditions at the first outlet 5 pounds pressure, and about 2000 feet per minute velocity. "This pressure of 5 pounds per square foot is for standard conditions of air, density corresponding to a barometric height of 30 inches, a temperature of 70 degrees Fahrenheit and a relative humidity of 70 per cent. Under these standard conditions a cubic foot of air weighs 0.07465 pound. The pressure of 5 pounds is equivalent to a pressure head of 67 feet of standard density air. A velocity of 2000 feet per minute corresponds to a velocity head of 17.27 feet. The total head then against which air is delivered to the supply main is 84.27 feet."

As the branches lead off do not change the size of the main until sufficient air has been removed to reduce the velocity to a value between 1200 and 1500 feet per minute. Then contract the mains with a taper of 1½ inches to the foot until the area is so reduced that the velocity again becomes about 2000 feet per minute. Repeat the contraction wherever necessary, but do not reduce the final diameter of the main to less than twice the diameter of the last branch.

A 15¼-inch diameter pipe is selected for the first section of the main, on account of giving the nearest velocity to 2000 feet per minute. After branches *A*, *B*, and *C* have been taken off the velocity is reduced to 1458 feet per minute. Being below 1500 feet per minute the main is reduced in size with a taper of 1½ inches to the foot to 13-inch diameter which increases the velocity to 2007 feet per minute. At the beginning of the 13-inch diameter or B.B. section of the main, the direction is changed 90 degrees which should be done with an elbow having a radius of throat not less than diameter of pipe. When branches *D* and *E* have been taken off the velocity becomes 1302 feet per minute; the main is again reduced in size with a taper 1½ inches to the foot to 10½-inch diameter increasing the velocity to 1995, and again branches *F* and *G* reduce the velocity to 1247 feet per minute, which necessitates changing the size of the main to 8¼-inch diameter, bringing the velocity up to 2020 feet per minute. Branches *H* and *I* again reduce it to 1212 feet per minute as the main should never be reduced to less than twice the diameter of the last branch but it can now only be reduced to about 7-inch diameter to be settled definitely later when sizes of branches are determined.

CHART FOR VENTILATION PIPES.

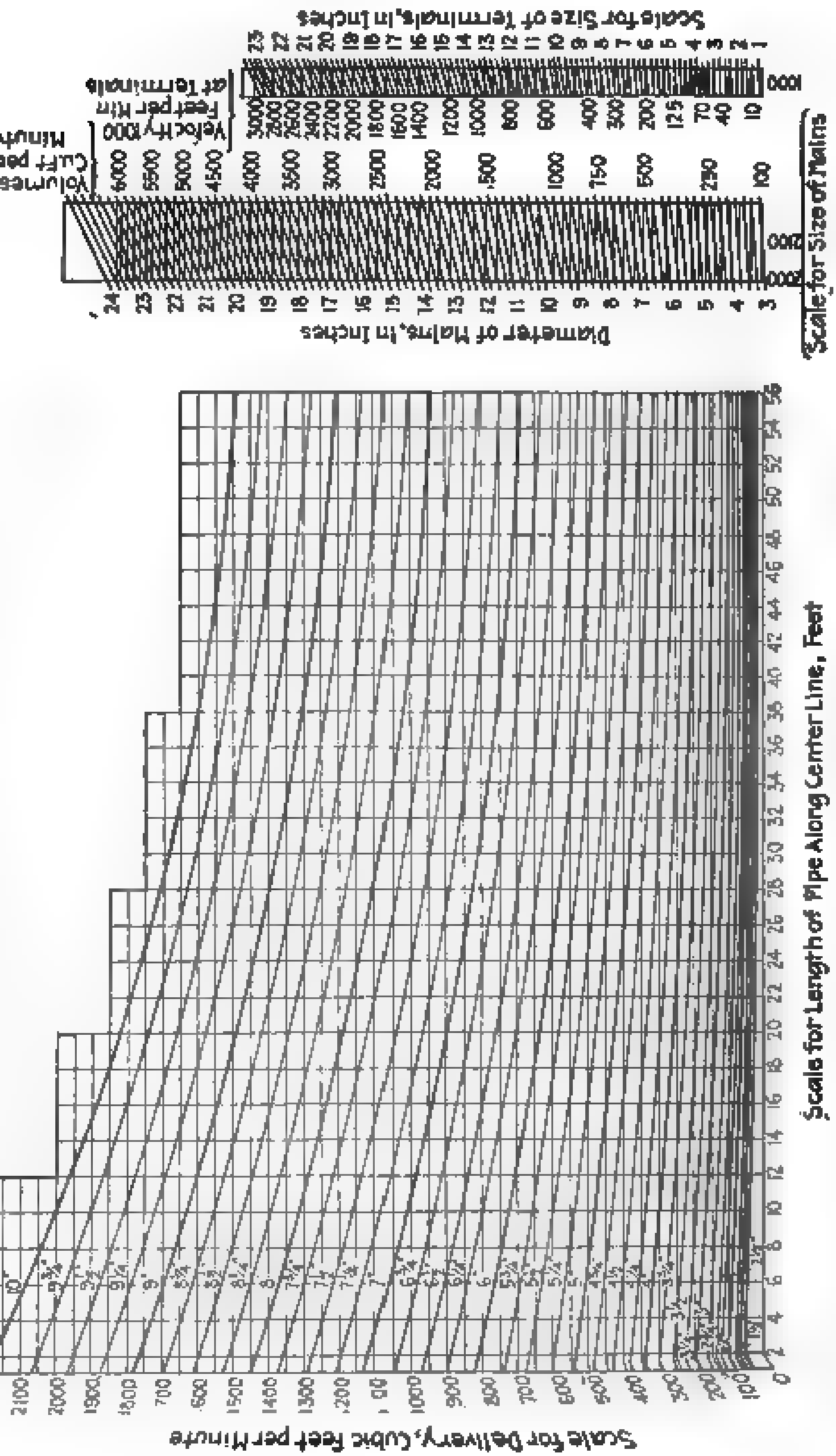


Fig. 180.

The formula for velocity in ventilation pipes is

$$\text{Area} = \frac{\text{Volume}}{\text{Velocity}}.$$

Knowing everywhere the size and the lead of the main, the next point to be considered is the size of the branches which is governed largely by the distance of the point of intersection of the branch with the main from the fan. This is due to the loss in delivery of air due to friction in the main up to this point.

The formula for loss of head in a round or square pipe is $H_F = 4\,F\frac{L}{d}V_1^2$, where H_F is loss of head in feet of air due to friction, F is the coefficient of friction, L and d are length and diameter of the pipe, respectively, both expressed in feet or both in inches, and V_1 is the velocity of flow through the pipe in feet per second. If we change V_1 to V or velocity in feet per minute and give F its proper value for first class piping, namely, 0.00008, we have upon substituting and reducing

$$H_F = \frac{L}{d}\,\frac{V^2}{11{,}250{,}000}.$$

For practical purposes it is only necessary to figure the loss of head in feet of air due to friction for each section of the main, and the size of all branches leading off from that section of the main should be governed by the loss of head figured for the entire section. Such being the case we should substitute for V in the formula for loss of head given above $\sqrt{\frac{V^2 V_2^2}{2}}$, where V is the velocity in feet per minute at the beginning of any section of the main and V_2 is the velocity in feet per minute at the end of the same section. This velocity is called the mean velocity for that section of the main. The main velocities for the different sections of the main on the accompanying sketch are as follows: —

Section A.A.

$$\text{M.V.} = \sqrt{\frac{(1970)^2 + (1655)^2}{2}} = 1819.$$

Section B.B.

$$\text{M.V.} = \sqrt{\frac{(2007)^2 + (1845)^2}{2}} = 1928.$$

Section C.C.

$$\text{M.V.} = \sqrt{\frac{(1995)^2 + (1787)^2}{2}} = 1894.$$

SECTION D.D.

$$M.V. = \sqrt{\frac{(2020)^2 + (1616)^2}{2}} = 1829.$$

SECTION E.E.

$$M.V. = \sqrt{\frac{(1684) + (842)^2}{2}} = 1331.$$

From the experiments above mentioned it was concluded that each foot of head lost means an approximate loss of about 0.6 of one per cent of delivery as compared with standard conditions. In consideration of this fact the percentage of loss in deliveries of air due to friction for the different sections of the main on the accompanying sketch is as follows: —

REMARKS.	EACH SECTION.	TOTAL FROM FAN.
	Per cent.	Per cent.
SECTION A.A. Diam.=15¼″, length=183″, M.V.=1819 $H_F = \frac{183 \times (1819)^2}{15.25 \times 11{,}250{,}000} = 3.53 \times 0.6 =$	2.12	2.12
SECTION B.B. Diam.=13″, length=134″, M.V.=1928 $H_F = \frac{134 \times (1928)^2}{13 \times 11{,}250{,}000} = 3.4 \times 0.6 =$	2.04	4.16
SECTION C.C. Diam.=10½″, length=88″, M.V.=1894 $H_F = \frac{88 \times (1894)^2}{10.5 \times 11{,}250{,}000} = 2.67 \times 0.6 =$	1.6	5.76
SECTION D.D. Diam.=8¼″, length=101″, M.V.=1829 $H_F = \frac{101 \times (1829)^2}{8.25 \times 11{,}250{,}000} = 3.64 \times 0.6 =$	2.18	7.94
SECTION E.E. Diam.=7″, length=48″, M.V.=1331 $H_F = \frac{48 \times (1331)^2}{7 \times 11{,}250{,}000} = 1.08 \times 0.6 =$	0.65	8.59

For general run of branches make the angle anything less than 45 degrees; 30 degrees is a very good angle, but it is not necessary to adhere to it rigidly. For the branches at the extreme end of the main, where the velocity is very much reduced, the angle should be increased and the last branch should generally lead off at 90 degrees.

In determining the inside diameter of the branches an allowance should be added to the length of the branch along centre line for elbow, as follows: — for one 90-degree elbow add

3 feet, for two add 7 feet, for three add 7 feet. For elbows less than 90 degrees add in proportion. This applies to elbows whose radius to the center of the pipe is 1½ diameters. A smaller radius should never be used. Take branch *J* for instance, where 225 cubic feet per minute are needed; the loss of delivery in the main up to this point is 8.59 per cent and the actual delivery to be expected will be only 0.9141 of the standard delivery; the standard delivery then would be $\frac{225}{0.9141} = 246$ cubic feet per minute. As branch *J* is about 17½ feet long and has two 90-degree elbows and one 45-degree elbow, we should add about 8½ feet to the length, which would make it 26 feet long. Now if the inside diameter of branch *J* is made of a size (see Fig. 330) to pass 246 cubic feet length 26 feet under standard conditions, it may be expected to give the required 225 cubic feet under actual conditions. The sizes of all branches are determined by the same method.

The length and size of branches being determined, connect these with their outlet fittings by a cone expanding 1½ inches to the foot to the desired diameter for the velocity required on the accompanying sketch. The outlet fittings are all shown adjustable elbows which are usually fitted on all supply systems on government vessels. Any style terminal may be used.

FIXED TERMINALS FOR EXHAUST PIPES.

A.	B.	C.	D	E	F.	G.	U.S.S.G. Gauge
In.	In.	In.	In.	In.	In.	In.	No.
2	3½	2	½	¾	1½	3	22
2½	4	2½	½	¾	1½	3	22
3	4½	3	½	¾	1½	3	22
3½	5	3½	½	¾	1½	3	22
4	6	4	½	¾	1½	3	22
4½	6½	4½	1	¾	1½	3	22
5	7	5	1	¾	1½	3	20
5½	7½	5½	1	¾	1½	3	20
6	8	6	1	¾	1½	3½	20
6½	8½	6½	1	¾	1½	3½	20
7	9	7	1	¾	1½	3½	20
7½	9½	7½	1	¾	1½	3½	20
8	10	8	1	¾	1½	3½	20

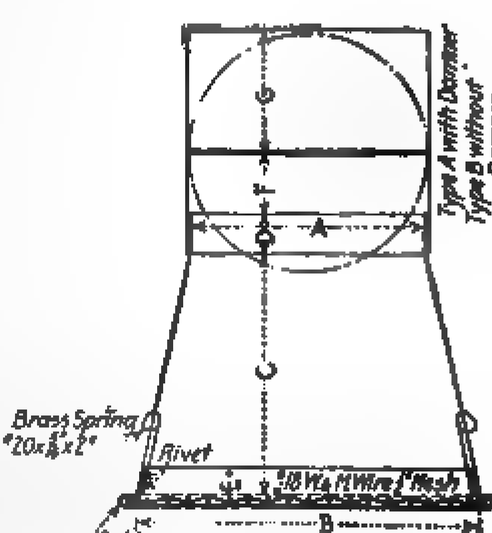


FIG. 331.

ADJUSTABLE TERMINAL.

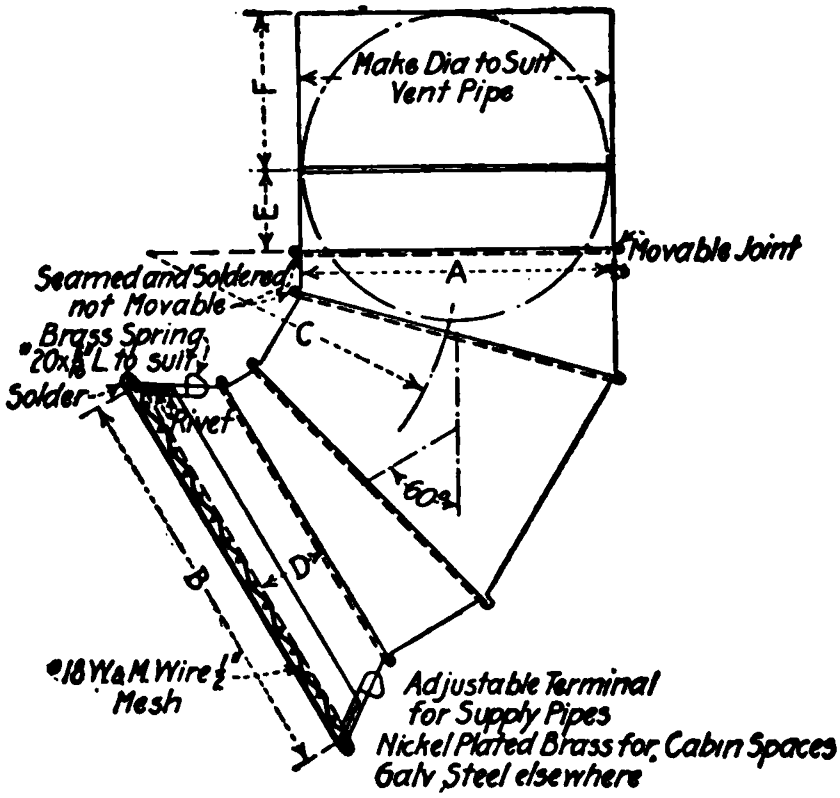


FIG. 332.

A.	*B.*	*C.*	*D.*	*E.*	*F.*	GAUGE. (U.S.S.G.)
			In.	In.	In.	No.
2	3½	2	1¼	1½	3	22
2½	4	2½	1¼	1½	3	22
3	4½	3	1¼	1½	3	22
3½	5	3½	1¼	1½	3	22
4	6	4	1½	1½	3	22
4½	6½	4½	1½	1½	3	22
5	7	5	1½	1½	3	20
5½	7½	5½	1½	1½	3	20
6	8	6	1½	1½	3	20
6½	8½	6½	1½	1½	3½	20
7	9	7	1½	1½	3½	20
7½	9½	7½	1½	1½	3½	20
8	10	8	1½	1½	3½	20
8½	10½	8½	1½	1¾	3½	20
9	11½	9	2	1¾	3½	20
9½	12	9½	2	1¾	4	20
10	12½	10	2	1¾	4	18
10½	13	10½	2	1¾	4	18
11	14	11	2	1¾	4	18
11½	14½	11½	2	1¾	4	18
12	15	12	2	1¾	4	18

ADJUSTABLE TERMINALS WITH DAMPERS.

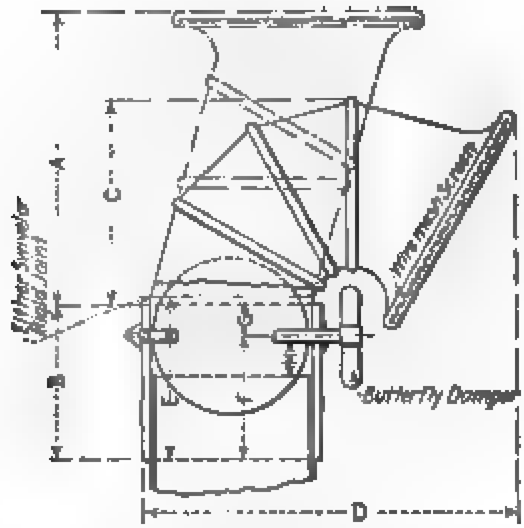


FIG. 233.

Note. Terminals to be Nickel Plated in Officers Quarters, elsewhere to be Galvanized

Size.	A.	N.P B.	C.	D.	N.P E.	N.P F.	N.P G.	H.	Galv. B.	Galv. E.	Galv. F.	Galv. G.
In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
2	5 1/2	1 15/16	3 1/2	6 1/2	1 15/16	1 1/2	5/16	1/2	2 7/16	2 7/16	1 3/4	5/8
2 1/2	6	1 15/16	4	7	1 15/16	1 1/2	5/16	1/2	2 7/16	2 7/16	1 3/4	5/8
3	6 1/2	1 15/16	4 1/2	8	1 15/16	1 1/2	5/16	1/2	2 7/16	2 7/16	1 3/4	5/8
3 1/2	7	2 3/8	5	8 1/2	2 1/2	1 15/16	7/16	11/16	2 13/16	3 1/16	2 1/16	3/4
4	7 1/2	2 3/8	5 1/2	9 1/2	2 1/2	1 15/16	7/16	11/16	2 13/16	3 1/16	2 1/16	3/4
4 1/2	8 1/2	2 3/8	6	10	2 1/2	1 15/16	7/16	11/16	2 13/16	3 1/16	2 1/16	3/4
5	9	2 13/16	6 1/2	11 1/4	2 1/2	1 15/16	7/16	11/16	2 13/16	3 1/16	2 1/16	3/4
5 1/2	9 1/2	2 13/16	7	12	2 15/16	2 5/16	1/2	13/16	3 1/4	3 1/2	2 1/2	7/8
6	10	2 13/16	7 1/2	13	2 15/16	2 5/16	1/2	13/16	3 1/4	3 1/2	2 1/2	7/8
6 1/2	10 1/2	2 13/16	8	13 1/2	2 15/16	2 5/16	1/2	13/16	3 1/4	3 1/2	2 1/2	7/8
7	11	2 13/16	8 1/2	14 1/2	2 15/16	2 5/16	1/2	13/16	3 1/4	3 1/2	2 1/2	7/8
7 1/2	11 1/2	3 5/16	9	15	3 7/16	2 11/16	9/16	15/16	3 13/16	4 1/16	2 15/16	1 1/16
8	12	3 5/16	9 1/2	16	3 7/16	2 11/16	9/16	15/16	3 13/16	4 1/16	2 15/16	1 1/16
8 1/2	12 1/2	3 5/16	10	16 1/2	3 7/16	2 11/16	9/16	15/16	3 13/16	4 1/16	2 15/16	1 1/16
9	13 1/2	3 5/16	10 1/2	18	3 7/16	2 11/16	9/16	15/16	3 13/16	4 1/16	2 15/16	1 1/16
9 1/2	14	3 13/16	11	18 1/2	3 15/16	3 1/8	3/4	1 1/16	4 7/8	5 1/8	3 9/16	1 5/16
10	15 1/2	3 13/16	12	20 1/2	3 15/16	3 1/8	3/4	1 1/16	4 7/8	5 1/8	3 9/16	1 5/16
10 1/2	16	3 13/16	12 1/2	21	3 15/16	3 1/8	3/4	1 1/16	4 7/8	5 1/8	3 9/16	1 5/16
11	16 1/2	3 13/16	13	22	3 15/16	3 1/8	3/4	1 1/16	4 7/8	5 1/8	3 9/16	1 5/16
11 1/2	17	3 13/16	13 1/2	22 1/2	3 15/16	3 1/8	3/4	1 1/16	4 7/8	5 1/8	3 9/16	1 5/16
12	17 1/2	3 13/16	14	23 1/2	3 15/16	3 1/8	3/4	1 1/16	4 7/8	5 1/8	3 9/16	1 5/16
12 1/2	18	4 5/16	14 1/2	24	4 7/16	3 1/2	13/16	1 1/4	5 3/4	6	4 1/4	1 9/16
13	19	4 5/16	15	25 1/2	4 7/16	3 1/2	13/16	1 1/4	5 3/4	6	4 1/4	1 9/16
13 1/2	20	4 5/16	16	26	4 7/16	3 1/2	13/16	1 1/4	5 3/4	6	4 1/4	1 9/16
14	21	4 5/16	16 1/2	27 1/2	4 7/16	3 1/2	13/16	1 1/4	5 3/4	6	4 1/4	1 9/16

The air is to be renewed in the various spaces approximately as follows, based on the gross capacity of the compartments, and on the above pressure:

Quarters on orlop deck, in from ten to twelve minutes.
Water closets, in from four to six minutes.
Storerooms, in from eight to twelve minutes.
Magazines, in from six to eight minutes.
Engine rooms and steering compartments, in about two minutes.
Ice-machine room, in about three minutes.
Dynamo rooms, in about three-fourths of a minute.

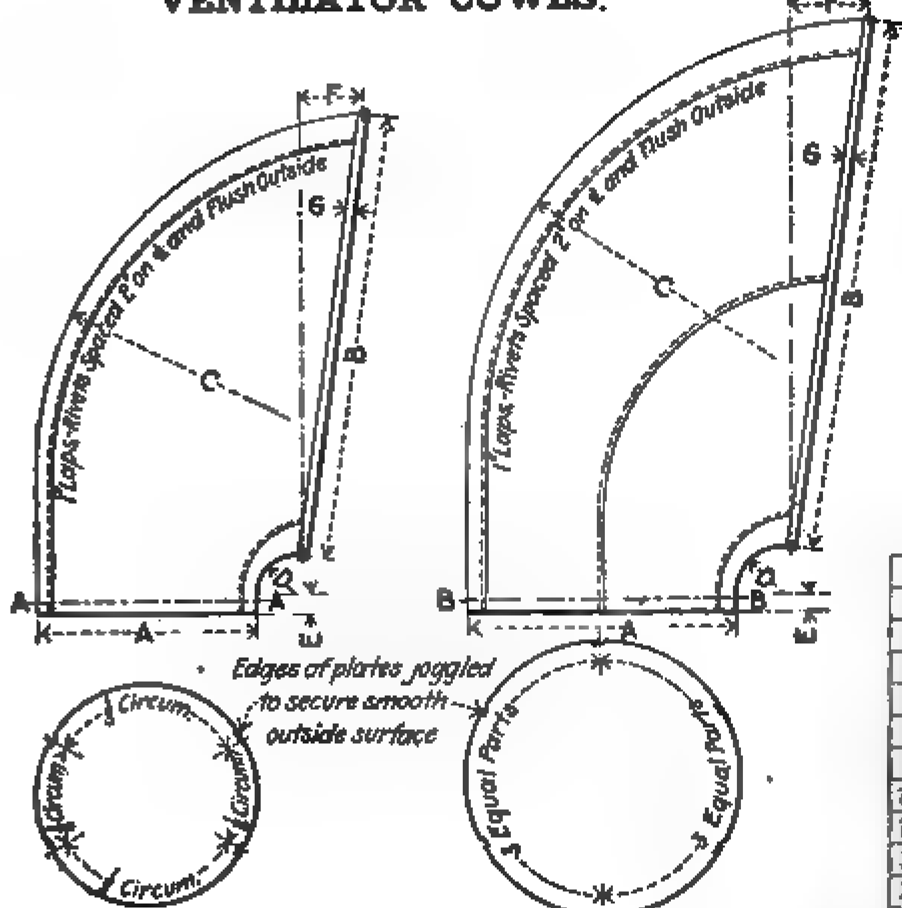
Fans: —

600 cubic feet.	5,000 cubic feet.
1,000 " "	6,000 " "
1,600 " "	8,000 " "
2,500 " "	10,000 " "
4,000 " "	12,000 " "

STANDARD SIZES OF VENTILATORS AND COWLS — U. S. N.

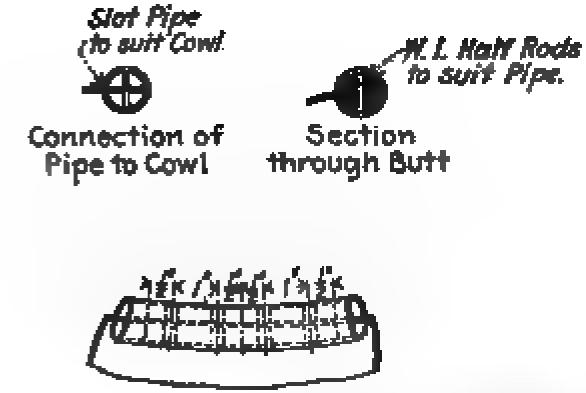
Diam. of Ventilators.	Diam. of Cowl, Large Opening.	Material for Ventilator Trunk, Hull Steel.	Material for Ventilators and Cowls.	
			Sheet Iron or Steel, U.S.S.G.	Soft Rolled Copper, Stubs Gauge.
10	20	U. S. S. G. 13	20″ gauge	16″ gauge
12	24	" 13	20″ "	16″ "
15	30	" 13	20″ "	16″ "
18	36	" 13	20″ "	16″ "
21	42	5 lbs.	16″ "	14″ "
24	48	5 "	16″ "	14″ "
27	54	5 "	16″ "	14″ "
30	60	5 "	16″ "	14″ "
36	72	7½ "	14″ "	12″ "
42	84	7½ "	14″ "	12″ "
48	96	7½ "	12″ "	12″ "
54	108	7½ "	12″ "	12″ "

VENTILATOR COWLS.



Section A-A
Type of Std. Ventilator Cowls. 30" Dia. and under.

Section B-B
Type of Std. Ventilator Cowls. 36" Dia. and over.



Connection of Pipe to Cowl

Section through Butt

Detail of Butt in Standard W.I. Pipe

A	B	C	D	E	F	G	GAUGE	RIVETS
10"	20"	16"	2	1/2"	3	1/2" Std. W.I. Pipe	No. 20 U.S.S.G.	4 Lb.
12"	24"	9"	2	1/2"	3 3/4"	· · · ·	· · ·	· ·
15"	2'-6"	24"	2 1/2"	1 1/2"	4 3/4"	· · · ·	· · ·	· ·
18"	3'-0"	2'-5"	3"	2"	5 1/2"	3/4" · · ·	· · ·	· ·
21"	3'-6"	2'-9"	3 1/2"	2"	6 1/4"	· · · ·	· 6 ·	5 ·
24"	4'-0"	3'-2"	4"	2"	7 1/4"	· · · ·	· · ·	· ·
2'-3"	4'-6"	3'-7"	4 1/2"	2 1/2"	8"	1" · · ·	· · ·	· ·
2'-6"	5'-0"	4'-0"	5"	2 1/2"	9"	· · · ·	· · ·	· ·
3'-0"	6'-0"	4'-9"	6"	2 1/2"	11"	· · · ·	· 14 ·	6 ·
3'-6"	6'-4"	6'-0"	6"	3"	11 1/2"	1 1/2" · · ·	· · ·	· ·
4'-0"	6'-8"	6'-3"	6"	3"	12"	· · · ·	· 12 ·	1/4" Dia.
4'-6"	7'-0"	6'-6"	6"	3"	12 1/2"	· · · ·	· · ·	·

FIG. 334.

WEIGHT OF STANDARD VENTILATOR COWLS.

Diameter of Ventilator Trunk.	Length of Parallel Neck below Centre of Throat Radius.	Area in Square Feet Plus Laps.	Weight of Cowl in Pounds, Exclusive of Fittings.	Thickness in U.S. Gauge.
In.	In.	Sq. Ft.	Lbs.	
10	2½	5.5	11.25	No. 18 U.S. G.
12	3	7.5	15.50	" "
14	3½	10.5	21.50	" "
16	4	13.75	28.00	" "
18	4½	17.50	35.75	" "
20	5	22.00	45.00	" "
22	5½	27.00	55.00	" "
24	6	32.50	66.25	" "
26	6½	39.00	79.50	" "
28	7	45.50	93.00	" "
30	7½	53.75	172.00	No. 14 "
33	8¼	64.50	205.00	" "
36	9	77.50	247.00	" "
42	10½	105.00	335.00	" "
48	12	135.00	430.00	" "

ELSWICK

Diam. of bore, ins......	1.46	1.46	1.85	1.85	1.85	1.85	2.24
Diam. of bore, mm.....	37	37	47	47	47	47	57
Len. of bore, cals........	25	45	40	50	50	46	40
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Wt. of gun..............	79	268	506	1067	852	560	840
Wt. of proj., lbs.........	1.1	1.5	3.3	3.3	3.3	3.3	6
	Oz.	Oz.	Oz.	Lbs.oz.			Oz.
Wt. of Cord., ch........	1.125	4.5	7.94	1 4¼	.....	.....	9.2
					Oz.	Oz.	
Wt. of M.D., ch........	.....	.....	.....	1 6	15.0	10.0	.....
Muz. vel. f. a...........	1540	2300	2132	2800	2700	2300	1968
Muz. ener. f. t...........	18	55	104	179	166	121	161
Pen. at muz., ins........	1.9	4.3	5.2	7.8	7.4	5.7	5.6
Rds. per min...........	.....	25	25	25	25	25	25

	How-itzer.			How-itzer.	How-itzer.		
Diam. of bore, ins......	4	4	4	4.3	4.7	4.7	4.7
Diam. of bore, mm.....	102	102	102	109.2	120	120	120
Len. of bore, cals.......	8.75	40	50	12.5	12	40	45
	Lbs.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.
Wt. of gun..............	220	26	42	7	8	42	53
Wt. of proj., lbs.........	20	31	31	40	35	45	45
				Oz.		Lbs.oz	Lbs. oz
Wt. of Cord., ch........	.....	.....	.....	15.75	.....	5 5	8 2½
	Oz.	Lbs.	Lbs.		Lbs.oz.		
Wt. of M.D., ch.........	9½	5½	11	.....	1 4½	.....	9 4
Muz. vel. f. a...........	950	2300	3000	980	1150	2200	2570
Muz. ener. f. t...........	125	1137	1934	266	321	1510	2061
Pen. at muz., ins........	.....	.....	16.0	.....	.....	11.6	15.2
Rds. per min...........	.....	12	12	.....	.....	12	12

GUNS.

				Jointed Gun.	Field.	Horse Artillery.	Field.
2.24	2.953	3	3	3	3	3	3.3
57	75	76	76	76	76	76	84
50	14.13	40	50	19.2	28	23	28
Cwt.	Lbs.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.
10½	210	12	18½	4	7½	6	9
6	11.75	12½	12.5	12.5	14.3	12.5	18.5
	Oz.	Lbs. oz.	Lbs. oz.				Lbs. oz.
......	7½	1 10	3 4	....	....	....	1 3¾
Lbs. oz.				Oz.	Oz.	Lbs. oz.	
1 3	......	2 0	4 0	13½	20½	1 4	1 8
2400	1100	2210	2800	1458	1755	1700	1635
240	98	423	680	185	305	250	336
8.0	......	8.8	11.6	....	....	....	....
25	20	20	20	15	15	20	20

4.7	5	5	6	6	6	6	7.5
120	127	127	152	152	152	152	190
50	32	8.4	12.2	40	45	50	45
Cwt.	Tons.	Cwt.	Cwt.	Tons.	Tons.	Tons.	Tons.
66	2	9	20	6.6	7.35	8.75	13.8
45	60	50	100	100	100	100	200
	Lbs.	Oz.		Lbs.	Lbs.	Lbs.	
......	8.5	11.5	....	18.3	26	36	....
Lbs. oz.	Lbs. oz.		Lbs. oz.				Lbs.
15 0	9 8	......	3 5	22	31	34	75
3000	2115	782	1000	2500	2800	2930	2850
2808	1861	212	693	4334	5436	5952	11,264
19.4	13.0	......	....	19.5	23.1	24.8	30.4
12	10	......	....	9	9	9	6

ELSWICK GUNS. — (*Continued.*)

					Jointed Gun.	Field.	Horse Artillery.
Diam. of bore, ins......	7.5	8	8	8.24	9.2	9.2	10
Diam. of bore, mm.....	190	203	203	210	234	234	254
Len. of bore, cals........	50	45	50	44	45	50	40
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Wt. of gun..............	15	18.0	21	18.1	26.75	28	31
Wt. of proj., lbs.........	200	250	250	308.6	380	380	450
				Lbs.			Lbs.
Wt. of Cord., ch........	.....	.....	.....	47	.....	.....	81.5
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	
Wt. of M.D., ch........	77.5	80	85	52	122	136	86.5
Muz. vel. f. a...........	2,950	2,800	2,950	2,300	2,750	3,000	2,400
Muz. ener. f. t...........	12,068	10,872	12,069	11,320	19,926	23,712	17,973
Pen. at muz., ins.......	32.0	32.2	34.8	27.0	35.9	39.8	29.9
Rds. per min...........	6	5	5	5	4	4	3

	Field.	How-itzer.			How-itzer.	How-itzer.
Diam. of bore, ins......	10	10	12	12	12	12
Diam. of bore, mm.....	254	254	305	305	305	305
Len. of bore, cals........	45	50	40	40	45	50
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Wt. of gun..............	36.25	36	48.5	51	59.3	69.0
Wt. of proj., lbs.........	500	500	850	850	850	850
			Lbs.			
Wt. of Cord., ch........	......	.....	141	.....	.....	.....
	Lbs.	Lbs.		Lbs.	Lbs.	Lbs.
Wt. of M.D., ch........	167	180	155	260	286	318
Muz. vel. f. a...........	2,800	2,900	2,400	2,650	2,800	2,960
Muz. ener. f. t...........	27,181	29,157	33,949	41,386	46,208	51,640
Pen. at muz., ins........	40.9	42.95	38.4	44.6	48.5	52.5
Rds. per min...........	3	3	2	2	2	2

7.5″ gun — 38 rds. in 1 min. 45 sec. from 4 guns; 35 rds. in 1 min. 45 sec. from 4 guns.
6″ gun — 74 rds. in 1 min. from 10 guns; 78 rds. in 1 min. from 10 guns.
4.7″ gun — 79 rds. in 1 min. from 8 guns.
4″ gun — 59 rds. in 45 sec. from 8 guns.
12 pr. gun — 10 rds. in 31 sec. from 1 gun.
Some results actually obtained under service conditions at a target.
12″ gun — 8 rds. in 2 min. 10 sec. from 1 turret (pr. of guns); 16 rds. in 2 min. 45 sec. from 2 turrets (4 guns).
9.2″ gun — 57 rds. in 2 min. from 6 guns; 44 rds. in 2 min. from 6 guns; 13 rds. in 2 min. from 2 guns.

VICKERS GUNS AND MOUNTINGS.

	37 MM. 30 CAL.	37 MM. 42.5 CAL.	3-PDR. 50 CAL.	6-PDR. 50 CAL.	MOUNTAIN 3 INS. 12½ PR. 14.3 CAL.
	c. q. l.	c. q. l.	c. q. l.	c. q. l.	c. q. l.
mounting com- with shield.....	4 1 10	4 3 20	11 3 0	14 2 0	7 3 0
of shield, ins....	0.1875	0.16	0.25	no	0.1
	q. l.	q. l.	c. q. l.		q. l.
hield...........	3 11	1 22	1 0 0	shield	1 17
f elevation......	16°	15°	20°	20°	25°
f depression.....	25°	20°	20°	10°	15°

	WEIGHT OF CARR. WITHOUT LIMBER.	WEIGHT OF CARR. AND LIMBER WITH 24 ROUNDS.	3 IN. SEMI-AUT. 50 CAL.	4 INS. 50 CAL.
	c. q. l.	t. c. q.	t. c. q. l.	t. c. q. l
mounting com- with shield......	11 3 0	1 5 1	1 0 2 0	2 4 2 0
of shield, ins.....	0.125	0.144	no	no
	q. l.	c. q. l.		
hield...........	2 0	1 0 15	shield	shield
f elevation......	16°	16°	20°	15°
f depression.....	6°	10°	10°	10°

	WEIGHT OF CARR. WITHOUT LIMBER.	4.7 INS. 45 CAL.	4.7 INS. 48.4 CAL.	WEIGHT OF CARR. WITHOUT LIMBER.
	c. q. l.	t. c. q. l.	t. c. q. l.	t. c. q. l.
nounting compl. shield..........	17 3 0	3 13 3 0	5 9 2 0	2 14 3 0
of shield, ins....	no	2 and 0.313	3	0.23
		c. q. l.	t. c. q. l.	c. q.
hield...........	shield	{ 17 0 0 1 1 0	1 12 2 0	3 3
f elevation......	50°	20°	20°	50°
f depression.....	5°	7°	10°	0°

VICKERS, SONS AND MAXIM

	37 mm. 30 Cal.	37 mm. 49.5 Cal.	3 Pdr. 50 Cal.	6 Pdr. 50 Cal.	3 Ins. 12½ Pr. 14.3 C.
Diam. of bore, ins......	1.457	1.457	1.85	2.244	3
Len. of bore, ins.........	43.5	62	92.5	112.2	42.94
Len. of gun, ins..........	73.75	94	98.9	118.6	47.23
Max. pr. in chamber, tons per sq. in.........	13	14	17	16	12
Wt. of charge, lbs.......	0.0782	0.1875	1.066	1.55	0.5
Wt. of proj., lbs.........	1	1.25	3.3	6	12.5
	c. q. l.	c. q. l.	c. q. l.	c. q. l.	c. q. l.
Wt. of gun..............	3 2 24	5 1 19	5 2 4	9 1 5	2 12 [illegible]
Muz. vel. f. s............	1800	2300	2800	2600	1150
Muz. energy f. t.........	22.5	45.85	79.4	281	115
Pen. of W. I. pl. at muz. Gavre form., ins......	1.9	3.3	6.7	7.5	....
Pen. of M. st. pl. at muz. Gavre form., ins.	1.5	2.6	5.1	5.4	....
Pen. of hard st. pl. at 3000 yds. Gavre form., ins..................	....	....	....	....	....
Rds. per minute........	300	300	30	28	20

	6 In. Howit.	6 Ins. 45 Cal.	6 Ins. 50 Cal.	7.5 Ins. 45 Cal.	7.5 Ins. 50 Cal.
Diam. of bore, ins......	6	6	6	7.5	7.5
Len. of bore, ins.........	94.5	269.5	300	337.5	375
Len. of gun, ins..........	102.8	279.2	310.07	349.2	386.7
Max. pr. in chamber, tons per sq. in.........	9.85	17.75	18	18	17.5
Wt. of charge, lbs.......	5.3	35.25	43	78.25	80.03
Wt. of proj., lbs.........	90.3	100	100	200	200
	c. q.	t. c. q.	t. c. q.	t. c. q.	t. c. q.
Wt. of gun..............	18 3	7 8 2	7 16 0	14 0 2	16 0 0
Muz. vel. f. s............	1285	3012	3190	2,875	3,007
Muz. energy f. t.........	1035	6290	7056	11,465	12,540
Pen. of W. I. pl. at muz. Gavre form., ins......	....	23.65	25.8	28.75	30.75
Pen. of M. st. pl. at muz. Gavre form., ins......	....	18.4	20	22.25	23.7
Pen. of hard st. pl. at 3000 yds. Gavre form., ins..................	....	6.3	7.2	8.9	9.35
Rds. per min............	....	10	10	8	8

GUNS AND MOUNTINGS.

Field.		3 In. S. Aut. 50 Cal.	4 Ins. 50 Cal.	4.33 In. Howit. 13.5 C.	4.7 Ins. 45 Cal.	4.7 Ins. 48.4 Cal.
Lt. 3 Ins. 22 Cal.	Hvy 2.95 Ins. 30 Cal.					
3	2.95	3	4	4.33	4.724	4.724
64.96	99.46	150	201.15	58.45	212.6	228.45
69.3	103.8	159.995	208.45	63.55	220	236.2
16	16.0	17	18	12.5	17	18
1	1.032	3.625	11.25	1.0	19	17
12.5	14.33	12.5	31	35.27	45	45.14
c. q. l.	c. q. l.	c. q. l.	t. c. q.	c. q.	t. c. q.	t. c. q.
2 0	7 2 6	19 0 0	2 1 3	7 1	3 3 3	3 2 0
1600	1660	2700	3030	1045	2925	3050
220	274	632	1975	267	2670	2910
....	....	9.65	16.0	....	16.65	17.8
....	....	7.5	12.4	....	12.9	13.8
....	....	....	....	....	....	....
25	20	25	15	....	12	12
8 Ins. .5 Cal.	9.2 Ins. 47 Cal.	9.2 Ins. 50 Cal.	10 Ins. 45 Cal.	10 Ins. 48.6 Cal.	12 Ins. 45 Cal.	12 Ins. 50 Cal.
8	9.2	9.2	10	10	12	12
388.75	429.3	460	450	486	540	600
400	442.35	473	464.6	500	557.55	617.7
18	18	18	18	18	18	18.5
90	170.5	184	190.5	172	356	344
216.7	380	380	478.4	496.6	850	850
t. c. q.	t. c. q.	t. c. q.	t. c. q.	t. c. q.	t. c. q.	t. c. q.
14 3 0	28 1 0	27 16 1	34 17 0	27 17 0	57 14 0	65 17 0
3,090	3,025	3,070	2,850	2,863	2,950	3,010
14,350	24,110	24,835	26,945	28,225	51,290	53,400
31.5	39.25	39.95	38.9	40.2	50.65	52.1
24.4	30.45	31.0	30.1	31.15	39.25	40.4
9.8	13.35	13.75	13.8	14.65	19.5	20.0
6	4	4	3	3	2	2

SCHNEIDER

Cal. in mm.	305		274.4		240	
Cal. in ins.	12.0	12.0	10.9	10.9	9.4	9.4
Length in cal.	45	50	45	50	45	50
Wt. in tons	52.9	57.3	38.5	41.7	25.8	27.9
Wt. of A.P. proj., lbs.	826	826	606	606	407	407
Wt. of charge*	......	......	......	......	......	......
Muz. vel., ft. sec	2,952	3,116	2,952	3,116	2,952	3,116
Muz. energy, ft. tons	50,007	55,717	36,670	40,859	24,667	27,487
Perf. of steel at muz. (ins.)	38.3	41.6	34.6	37.4	30.1	32.3
Perf. of steel at 3000 yds. (ins.)	29.3	31.9	25.5	27.8	21.2	23.

Cal. in mm.	120		100		75	
Cal. in ins.	4.7	4.7	3.3	3.9	2.9	2.9
Length in cal.	45	50	45	50	50	60
Wt. in tons	3.2	3.5	1.9	2.0	0.85	1.2
Wt. of A.P. proj., lbs.	48	48	28.6	28.6	14.3	14.3
Wt. of charge*	......	......	......	......	......	......
Muz. vel., ft. sec.	2952	3116	2952	3116	2871	3035
Muz. energy, ft. tons	2932	3268	1734	1931	820	917
Perf. of steel at muz. (ins.)	13.9	15.0	11.6	12.5	9.3	10.0
Perf. of steel at 3000 yds. (ins.)	6.4	6.9	4.6	4.9	.....	.....

* No

MANILA ROPE.

Circumference of Rope.	Diameter of Rope.	Wt. per Foot.	Breaking Stress.	Circumference of Rope.	Diameter of Rope.	Wt. per Foot.	Breaking Stress.
		Lbs.	Lbs.			Lbs.	Lbs.
$\frac{1}{2}$	$\frac{3}{16}$	.035	405	$4\frac{3}{4}$	$1\frac{1}{2}$	.640	16,200
$\frac{3}{4}$	$\frac{1}{4}$	.045	585	5	$1\frac{5}{8}$	.720	20,000
1	$\frac{5}{16}$	.055	700	$5\frac{1}{2}$	$1\frac{3}{4}$	.835	23,650
$1\frac{1}{8}$	$\frac{3}{8}$	.065	900	6	$1\frac{7}{8}$	1.05	27,000
$1\frac{1}{4}$	$\frac{7}{16}$	.075	1,170	$6\frac{1}{4}$	2	1.15	29,250
$1\frac{1}{2}$	$\frac{1}{2}$	.085	1,800	$6\frac{1}{2}$	$2\frac{1}{8}$	1.25	31,690
$1\frac{3}{4}$	$\frac{9}{16}$	.110	2,295	7	$2\frac{1}{4}$	1.42	33,800
2	$\frac{5}{8}$	.140	3,200	$7\frac{1}{2}$	$2\frac{3}{8}$	1.70	36,750
$2\frac{1}{4}$	$\frac{3}{4}$	.170	3,750	8	$2\frac{9}{16}$	2.00	39,200
$2\frac{1}{2}$	$\frac{13}{16}$	.200	4,050	$8\frac{1}{2}$	$2\frac{3}{4}$	2.30	50,000
$2\frac{3}{4}$	$\frac{7}{8}$	.240	6,050	9	$2\frac{7}{8}$	2.65	54,190
3	1	.275	7,200	$9\frac{1}{2}$	3	3.00	57,800
$3\frac{1}{4}$	$1\frac{1}{16}$	.325	7,875	10	$3\frac{3}{16}$	3.40	75,000
$3\frac{1}{2}$	$1\frac{1}{8}$	.360	9,800	11	$3\frac{1}{2}$	4.00	96,000
$3\frac{3}{4}$	$1\frac{3}{16}$	.410	10,500	12	$3\frac{3}{4}$	4.70	101,000
4	$1\frac{1}{4}$	.460	11,250	13	$4\frac{1}{4}$	5.65	117,000
$4\frac{1}{4}$	$1\frac{3}{8}$	.510	13,500	14	$4\frac{7}{8}$	6.50	158,300
$4\frac{1}{2}$	$1\frac{7}{16}$	.585	14,450	15	$5\frac{1}{2}$	7.50	172,500

HEMP CORDAGE.

Circumference of Rope.	Number of Threads.	Weight per Foot (Tarred).	Breaking Stress.	Weight per Foot (White).	Breaking Stress.	Kind.
In.		Lbs.	Lbs.	Lbs.	Lbs.	
½	6	.018	336	.015	476	
¾	12	.037	672	.031	1,008	40 Thread
1	15	.047	896	.039	1,344	Yarn Hemp.
1¼	21	.062	1,120	052	1,680	
1½	33	.098	1,680	.083	2,352	Tarred is
1¾	42	.125	2,240	.105	3,136	Riga.
2	54	.161	3,024	.134	4,144	
2¼	66	.196	3,808	.160	5,162	White is
2½	84	.250	4,480	.208	6,496	Italian.
2¾	102	.302	5,600	.240	7,800	
3	120	.355	6,720	.296	9,408	
3¼	105	.414	7,840	.331	11,000	30 Thread
3½	123	.485	8,512	.403	12,544	Yarn Hemp.
4	159	626	11,200	.522	16,240	Tarred is
4½	201	791	14,448	.661	20,720	Riga.
5	249	.905	17,696	816	25,760	White is
6	360	1 40	25,760	1 18	36,960	Italian.
6½	351	1 66	28,672	1 40	43,200	25 Thread
7	408	1.92	33,152	1 61	47,000	Yarn Hemp.
7½	468	2 07	38,000	1 85	51,520	Tarred is St.
8	534	2 52	43,456	2.11	58,240	Petersburg.
9	675	3.18	53,760	2 66	73,920	White is
12	1,200	5.65	96,500	4 72	131,040	Italian.

Hemp. — Hemp rope deteriorates rapidly when exposed to wind and weather, and for this reason, when practicable, it is tarred, although doing so weakens it. Hemp should only be used for warps and bolt ropes of sails, as it is much too hard for other purposes, more especially when wet.

The following rules give the equivalent circumference of tarred and white hemp rope for a working load in tons of one third the breaking stress: —

$$\sqrt{7 \times \text{load}} = \text{circumference of white rope.}$$
$$\sqrt{9 \times \text{load}} = \text{circumference of tarred rope.}$$

Other Rope. — A variety of small stuff is used in ship work for sundry purposes, the principal kinds of which, and their purposes, follow : —

Cotton Rope is only used for halliards and sheets in small craft, being much softer than Manila.

Houseline is used for lacing sails, etc.

Marline is a small kind of tarred hemp, used for serving ropes and splices.

Serving twine (tarred or waxed) is used for whipping the ends of ropes and other small jobs.

COIR ROPE.

Circumference of Rope.	Diameter of Rope.	Weight per Foot.	Breaking Stress.	Circumference of Rope.	Diameter of Rope.	Weight per Foot.	Breaking Stress.
In.	In.	Lbs.	Lbs.	In.	In.	Lbs.	Lbs.
$2\frac{1}{2}$	$\frac{13}{16}$	.100	1,064	6	$1\frac{7}{8}$	.568	6,384
3	1	.142	1,568	7	$2\frac{1}{4}$	.775	8,612
$3\frac{1}{2}$	$1\frac{3}{16}$	.193	2,072	8	$2\frac{9}{16}$	1.003	10,864
4	$1\frac{1}{4}$	.251	2,856	9	$2\frac{7}{8}$	1.280	14,336
5	$1\frac{5}{8}$	.392	4,480	. . .	. . .	. . .	. . .

LENGTH OF REEL

For 100 Fathoms of Manila.

(Cores $4\frac{1}{2}''$ Diameter.)

Circumference of Rope.	Diameter of Reel.	Length of Roller.	Length of One Coil.	Circumference of Rope.	Diameter of Reel.	Length of Roller.	Length of One Coil.
"	"	"	′ ″	"	"	"	′ ″
$3\frac{1}{2}$	24	20	34 0	6	24	59	22 0
$3\frac{1}{2}$	30	13	55 6	6	30	43	25 0
4	24	25	30 0	$6\frac{1}{2}$	24	63	19 0
4	30	16	49 0	$6\frac{1}{2}$	30	46	27 0
$4\frac{1}{2}$	24	35	25 0	7	24	70	16 0
$4\frac{1}{2}$	30	20	43 0	7	30	50	26 0
5	24	43	23 0	$7\frac{1}{2}$	24	75	18 0
5	30	27	38 4	$7\frac{1}{2}$	30	53	26 0
$5\frac{1}{2}$	24	51	22 6	8	24	80	17 9
$5\frac{1}{2}$	30	35	31 6	8	30	55	27 0

CHAPTER II.

BLOCKS.

Blocks are divided broadly into two varieties, wood and iron, the former being used when reeving falls or tackles of Manila, and the latter for wire rope. Wood blocks are either "made" or "mortised," and may have metal or lignum-vitæ sheaves. The space in the block between the wood and the sheave is called the "swallow," the opposite end of the block being named the "breech," and the sides the "cheeks." The frame of the block may be strapped with iron or rope, a score being cut to form a housing for same.

All good blocks should be fitted with patent roller sheaves, especially for halliards and sheets, or for any heavy work. For topsail, sheet, throat and peak halliard purchases, etc., ash blocks, rope stopped, should be used. For derricks on freighters, where wire rope is used for heavy loads, iron blocks are best; where Manila falls and topping lifts are fitted, wood blocks are most suitable.

It will be evident that a good deal of power can be wasted by friction of the sheave on pin, and also by the rope chafing, through insufficient "swallow." To minimize the loss due to friction through the former cause, the pins should be bushed. Various bushings are employed for this purpose, probably the most efficient being a gunmetal or bronze sheave with spotted graphite next the pin.

The loss due to friction is 10 per cent for each sheave.

Blocks are designated "single," "double," or "treble," in accordance with the number of sheaves fitted, and are variously named to denote either a particular shape or as indicating the purpose for which they are intended. Some of the more common ones are: —

Snatch Blocks are used to divert the lead on the hauling part of a fall or tackle, having for this purpose a hinged part on one of the cheeks, to permit of placing the rope in, which would otherwise require reeving — a tedious and often impracticable process. They are usually fitted at heels of derricks, and on deck, to take warping and other leads, and are mostly made of iron, the old-fashioned wood snatch block being clumsy and cumbersome.

Fiddle Blocks take the name from their resemblance to the instrument, being constructed with two sheaves placed tandem, to permit of reeving separate halliards leading in opposite directions.

They are to be found on peak-halliards, at preventer stay tackles, etc., and are made in wood where Manila is rove, and in iron for wire rope.

Gin Blocks are used on derrick heads and spans in conjunction with a whip for handling cargo, and comprise a skeleton frame and sheave of iron.

Cat and Fish Blocks are fitted to the anchor davit, or crane, and consist of a pair of blocks with double or treble sheaves, having a large swallow. The fish (or lower) block has a large hook, sometimes made to trip, for fishing the anchor by the gravity band on the stock. These blocks are made in both wood and iron, the latter being often fitted with Manila falls.

Clump Blocks are made short and thick, as their name implies. They are used for tacks and sheets, and for this reason are extra large in the swallow. Made in wood and iron.

Wrecking Blocks are large, extra heavy iron strapped blocks, with lashing shackles, and are used for rigging up special derricks for temporary use with heavy loads.

Cheek-Blocks have only one side, the other cheek being formed by fitting against a spar.

The **size** of a block is designated by the length of the shell, and this is determined from the circumference of the rope which it reeves, as a unit. For most purposes three times the size of rope gives a suitable block, but in a few cases, where the minimum of friction and extra ease is desired in the swallow, as with blocks for boat davit tackles, three and one half times should be taken, *e.g.*, a block for ordinary purposes to reeve three-inch Manila would be 9 inches, but if required for davit falls, the size would be increased to 10 inches. The diameter of sheave is usually about two thirds of the size of block, a 12-inch block having an 8-inch diameter sheave.

In ordering blocks it is necessary to prepare a list, giving a concise but full and exact description of each individual block, embracing the following points: —

Sheaves. — The number of sheaves to be indicated by "S," "D," or "T," and whether of lignum-vitæ, brass, or iron sheaves, bushed or patent roller bushed.

Name. — The purpose for which the block is intended should be given, as, "jib-sheets," "derrick falls," etc.

Shackles should be very clearly specified where they are for special fittings. Ordinarily the shackle is fitted with its pin at right angles to the axis of the sheave, this being the most natural

way to engage the strap of block, therefore when the word "shackle," without further description, is used, it is always fitted in this manner. Where, however, it is essential to have it with the shackle pin running parallel with sheave pin (as is often necessary to get the falls of a tackle to lead in *line* with hauling part) the words "reverse shackle" must be used. If the shackle be required with its jaw uppermost, "reverse upset shackle" should be specified.

It often happens that a block is required with an eye to engage a shackle, which the blockmaker is not required to furnish. In such cases it is well to state whether the eye should be "worked" or a "shackle-eye" wanted. A "worked eye," of course, is one having its edge worked round like a ring, the "shackle-eye" being drilled straight through, so that the inserted pin bears along its entire length. For a given diameter of pin, that in a shackle-eye would be twice as strong as the one bearing on a worked eye, so that where other considerations do not count, it is economy to fit a shackle eye.

Beckets are small eyes fastened at the breech end of blocks to take the thimble on the standing part of a tackle. They are useful to have on all spare tackle blocks.

Strops. — When blocks are intended for brace or guy pendants, they should be specified as having a score cut to receive the rope strop.

Hooks should not be used on blocks where heavy loads are dealt with. For loads under ten tons they are equally reliable with shackles, besides being handier. They should be specified as "loose," "stiff front," "side," or "swivel" hook, as required, and the working load given in all cases, as many of the hooks on low grade blocks are considerably inferior in strength to the other parts of the fitting.

Sister, or Match Hooks are used for a variety of purposes, and consist of two hooks on a common eye, arranged to open, and when closed, to form a seemingly solid eye.

Lashing Shackles are especially large in the bow, and wider at the jaws, than ordinary shackles, being fitted to the heavier classes of double and treble blocks, to permit of their taking a Manila or wire rope lashing.

Swivel Jaws are sometimes fitted to the upper block in davit tackles.

Appended is a table giving actual weights of blocks, fitted with shackles and beckets complete, which will be of use in estimating rigging and outfit weights.

GUNS.

210		200		175		150	
8.3	8.3	7.9	7.9	6.9	6.9	5.9	5.9
45	50	45	50	45	50	45	50
17.3	18.6	14.9	16.2	10.0	10.8	6.3	6.8
275	275	231	231	165	165	99	99
......	......	......	....	....	....	....	....
2,952	3,116	2,952	3,116	2,952	3,116	2952	3116
16,667	18,572	14,002	15,601	10,000	11,143	6001	6886
26.2	28.3	24.3	26.3	22.1	23.9	18.2	20.1
17.5	19.2	16.1	17.3	13.8	15.2	10.2	11.8

65		57		47	37
2.5	2.5	2.21	2.21	1.8	1.4
50	60	50	60	60	60
0.55	0.76	0.45	0.55	0.30	0.17
8.8	8.8	6	6	3.3	1.76
....	....	....	....	....	....
2952	3116	2952	3116	3116	3116
533	594	362	400	223	119
7.9	9.1	7.1	7.5	5.9	5.0
....	....	....	....	....	....

stated.

KRUPP GUNS.

NAVAL GUNS.

Cal. in cm.	7.5			10.5			12			15		
Cal. in ins.	2.95			4.13			4.72			5.91		
Tot. Len. of Gun in Cals.	40	45	50	40	45	50	40	45	50	40	45	50
Tot. len. of gun in ft.	9.84	11.07	12.30	13.78	15.5	17.22	15.75	17.7	19.69	19.55	22.00	24.44
Len. of bore, ins.	108.66	123.43	138.19	153.55	174.21	194.89	175.20	199.25	222.45	218.12	247.49	276.78
Wt. of gun, lbs.	1488	1711	1936	3748	4189	4740	5512	6283	7055	10,582	12,015	13,558
Wt. of gun, tons	0.66	0.76	0.86	1.67	1.86	2.11	2.45	2.79	3.14	4.70	5.34	6.03
Wt. of st. proj. in lbs.	11.5	11.5	11.5	30.86	30.86	30.86	46.30	46.30	46.30	90.39	90.39	90.39
	14.6	14.6	14.6	39.68	39.68	39.68	59.52	59.52	59.52	112.4	112.4	112.4
Wt. of ch. in lbs.	2.77	3.12	3.54	10.47	12.57	14.33	15.66	17.97	20.62	29.99	34.40	39.47
Muz. vel. in ft.-secs.	2690	2890	3068	2835	3022	3199	2877	3038	3225	2854	3008	3196
	2388	2566	2723	2500	2661	2822	2539	2677	2841	2556	2697	2858
Muz. energy tot. ft.-tons	576	665	749	1720	1952	2191	2659	2969	3340	5099	5680	6389
Per. thro. steel in ins.	7.13	7.91	8.53	10.87	11.92	12.93	12.87	13.90	15.15	16.15	17.41	18.98
Per. thro. iron, Tresidder's formula	9.9	11.0	11.7	14.7	17.24	18.77	18.35	19.91	21.77	26.66	24.52	26.84
Per. Krupp st., 3000 yds.	.....	.....	.....	.....	.....	.....	3.52	3.74	4.02	4.98	5.29	5.66

KRUPP GUNS. — (*Continued.*)

NAVAL GUNS.

Cal. in cm. / Cal. in Ins.	21 / 8.27			24 / 9.45			28 / 11.02			30.5 / 12.01		
Tot. Len. of Gun in Cals.	40	45	50	40	45	50	40	45	50	40	45	50
Tot. len. of gun in ft.	27.56	30.5	34.45	31.50	35.4	39.37	36.75	41.3	45.93	40.3	45.0	50.03
Len. of bore, ins.	305.91	347.29	388.59	350.80	398.28	445.28	409.46	464.62	519.70	445.67	505.95	565.76
Wt. of gun, lbs.	29,321	33,279	37,258	44,092	50,265	56,438	70,105	79,907	89,507	90,609	103,174	120,141
Wt. of gun, tons	13.03	14.80	16.56	19.60	22.34	25.09	31.16	35.48	39.79	40.28	44.86	51.45
Wt. of st. proj. in lbs.	249.1 308.6	249.1 308.6	249.1 308.6	374.48 474.0	374.48 474.0	374.48 474.0	595.2 460.6	595.2 460.6	595.2 460.6	771.6 981.0	771.6 981.0	771.6 981.0
Wt. of ch. in lbs.	82.47	94.59	108.71	124.58	143.10	164.27	198.41	227.07	262.35	255.73	293.21	337.30
Mus. vel. in ft.-secs.	2,851 2,559	3,015 2,707	3,196 2,868	2,854 2,533	3,018 2,687	3,199 2,845	2,854 2,523	3,018 2,664	3,202 2,835	2,854 2,526	3,018 2,674	3,199 2,838
Muz. energy tot. ft.-tons	14,037	15,684	17,620	21,169	23,718	26,655	33,561	37,595	42,435	42,564	48,728	54,859
Per. thro. steel in ins.	23.20	25.13	27.30	26.96	29.20	31.73	31.80	34.45	37.48	34.94	37.84	41.10
Per. thro. iron, Tresidder's formula	31.73	34.51	37.65	36.47	39.66	43.27	42.52	46.28	50.57	46.42	50.47	55.08
Per. Krupp st., 3000 yds.	8.14	8.65	9.22	9.84	10.45	11.13	12.11	12.86	13.70	13.58	14.41	15.39

BETHLEHEM

ORDNANCE.

Cal.	Len. of Bore in Cal.	Cal.	Wt. of Gun	Wt. of Proj.	At Muzzle.		Per. of W.I. Gavre Formula.	At 3000 Yds. Range.		
					Velocity.	Energy.		Dangerous Space for Target 25′ High.	Energy.	Per. of B. Hard-faced Arm. Pierc. Proj. with Normal Impact.
Ins.	Cals.	Cms.	Lbs.	Lbs.	Ft.-lb. sec.	Ft.-tons.	Ins.	Yds.	Ft.-tons.	Ins.
1 457	50	3 7	120	1	2150	37	.	.	.	. .... .
1 831	50	4 7	550	3	2400	119	. .		...	....
2 244	50	5 7	960	6	2400	240			...	.. ..
3	50	7 62	1900	13	2800	707	.	.	.	. ....
			Tons.							
4	45	10 16	2 3	33	2600	1545	9 8	240	755	....
4	50	10 16	2 6	33	3000	[illegible]	12 1	315	1,000	. .. .
5	45	12 7	3 4	60	2600	2810	12 8	255	1,575	......
5	50	12 7	4 75	60	3000	3745	15 8	340	2,035	. .
6	45	15 24	7 2	105	2600	4965	16 9	275	2,970	6 9
6	50	15 24	8 4	105	3000	6550	20 0	365	3,950	8 3
7	45	17 78	12 7	165	2800	8965	23 2	330	5,790	9 5
7	50	17 78	14 5	165	3000	10,300	25 5	385	6 640	10 4
8	35	20 32	15 2	316	2250	10,500	28 3	235	5,240	11 0
8	45	20 32	18 6	260	2800	14,230	29 1	350	9,800	12 3
8	50	20 32	22 3	260	3000	16,220	32 2	405	11,350	13 4
10	35	25 4	30 0	604	2250	21,200	38 6	245	16 580	14 8
10	45	25 4	35 4	515	2800	27,990	40 8	370	21 080	17 2
10	50	25 4	43 9	515	3000	32,110	44 7	430	24,070	18 7
12	35	30 48	52 0	1046	2250	36,700	50 1	250	29,880	19 1
12	45	30 48	53 8	870	2800	47,290	51 7	380	36 790	21 7
12	50	30 48	66	870	3000	54,280	57 1	435	42,350	23 7
14	35	35 56	57 4	1660	2150	53,190	50 4	230	44 660	22 3
14	45	35 56	70 3	1350	2450	56,170	52 4	295	45 090	22.4
18	30	45 72	60 0	2075	2150	66,490	49 2	225	52,750	21 1

Guns less than 3″ cals. are chambered for fixed ammunition with the powder and projectiles in brass cartridge cases. Guns from 3″ cals upwards, and including the 6″ L 45 gun, can be chambered to use either fixed ammunition, or loose ammunition with the powder in cartridge bags and the projectile separate from the powder. Guns above 6″ cal and including the 6″ L 45 gun are chambered for loose ammunition. The breech mechanisms of all guns up to 10″ are operated by

TEEL COMPANY.

ORDNANCE.

At 8000 Yds. Range.			Limiting Ranges beyond which Capped Arm. Pierc. Proj. will not perforate Krupp Hard-faced Arm. of 12″ and 7″ thickness.		Cal.
Dangerous Space for Target 25′ high.	Energy.	Perf. of B. Hard-faced Arm. by Capped Arm. Pierc. Proj. with Norm. Impact.	12″ plate.	7″ plate.	
Yds.	Ft.-tons	Ins.	Yds.	Yds.	Ins.
....	....	....	....	....	1.457
....	....	....	....	....	1.851
....	....	....	....	....	2.244
....	....	....	....	....	3
....	....	....	....	....	4
....	....	....	....	....	4
....	....	....	....	....	5
....	....	....	....	....	5
55	1,307	4.1	....	2,870	6
75	1,749	4.9	....	4,500	6
70	2,285	6.1	....	6,350	7
85	3,267	6.7	....	7,310	7
60	5,060	8.1	....	10,230	8
85	5,457	8.6	3,240	10,420	8
95	6,235	9.0	4,420	11,610	8
65	11,120	11.5	7,300	Max. range	10
95	13,160	12.8	9,075	" "	10
115	15,150	13.9	10,560	" "	10
70	21,700	15.6	14,180	" "	12
105	24,615	16.9	14,560	" "	12
120	28,135	18.3	16,330	" "	12
70	33,650	18.7	Max. range	" "	14
85	32,030	18.1	" "	" "	14
65	36,360	16.7	15,100	" "	18

single motion of a hand-lever. Those of the larger guns are operated by the olution (3 to 5 turns) of a crank.

The 8″, 10″ and 12″ L 50 guns, and the 14″ L 45 gun are for use in turrets, and are great weight at the breech in order to balance the long muzzles, so that a comatively small barbette may be used.

UNITED STATES

Gun.	Mark.	Len. in Cal.	Tot. Len.	Cap. of Chamber in Ins.	Travel of Proj. in Ins.	Wt. of Gun.	Wt. of Proj.	Wt. of Charge.
			Ins.			Tons.	Lbs.	Lbs.
3" R.F.G.	II, III	50	154	219	128 3	0 9	13	3 86
3" S.A.	V, VI	50	159	219	128 3	1 0	13	3.86
4" R.F.G.	III, IV, V, VI	40	164	331	134 5	1 5	33	4 86
4" "	VII	50	205	652	168 3	2 6	33	9 0
4" "	VIII	50	205	652	168.3	2 9	33	12.3
5" "	II, III, IV	40	206	656	167 8	3 1	50	10 0
5" B.L.R.	V, VI	50	256	1,200	215 6	4 6	60	19.2
5" "	VI	50	256	1,200	215 6	4 6	[illegible]	20 5
5" R.F.G.	VII	51	261	1,165	215 6	5 0	50	23.8
6" R.F G.	II, III	30	196	1,318	145 4	4 8	105	18 8
6" "	IV, VII	40	256	1,320	205 8	6 0	[illegible]	18 8
6" "	IX	45	270	1,320	221 7	7 0	105	18 8
6" B.L. R.	VI	50	300	2,101	247 5	8 8	105	30 0
6" "	VIII	50	300	2,101	247 5	8 6	105	37 0
7" B.L.R.	II	45	323	3,643	259 8	12 7	165	68 0
8" B.L.R.	III, IV	35	305	3,170	245 8	13 1	260	48 5
8" "	V	40	343	5,243	273 1	18 1	260	78 0
8" "	VI	45	369	5,243	299 1	18 7	260	98.5
10" "	I, II	30	329	6,779	251 1	25 1	510	90.0
10" "	III	40	413	7,222	327 0	34 8	510	207.5
12" "	I, II	35	441	11,991	345 2	45 3	870	160 0
12" "	III, IV	40	493	17,096	392 2	52 1	870	237 5
12" "	III, IV	40	493	17,096	392 2	52 1	870	305 0
12" "	V	45	553	16,974	452 0	52 9	870	305 0
12" "	VI	45	553	14,970	452 0	53 6	870	340 0
12" "	VII	50	607	14,296	506 3	56 1	870	340 0
13" "	I, II	35	479	15,068	374 9	61 4	1130	180 0
14" "	II	45	642	.	.	63 1	1400	365 0

* Harveyized

NAVAL ORDNANCE.

Muz. Vel.	Muz. Energy	Pen. at Muz. Krupp Arm. Using Capped Proj.	At 3000 Yds.		At 6000 Yds.		At 9000 Yds.	
			Remaining Vel.	Penetration.	Remaining Vel.	Penetration.	Remaining Vel.	Penetration.
Ft.-sec.	Ft.-tons.	Ins.	Ft.-sec.	Ins.	Ft.-sec.	Ins.	Ft.-sec.	Ins.
2700	658	3.3	1230	1.2	848	0.8	......	......
2700	658	3.3	1230	1.2	848	0.8	......	......
2000	915	3.4	1156	1.7	897	1.2	......	......
2500	1,430	4.6	1432	2.2	979	1.4	853	1.2
2800	1,794	5.3	1627	2.6	1033	1.5	878	1.2
2300	1,834	5.3	1286	2.6	934	1.7	829	1.4
2700	3,032	6.2	1692	3.5	1102	2.0	928	1.6
3000	3,122	6.4	1732	3.2	1057	1.7	877	1.4
3150	3,439	6.8	1835	3.5	1091	1.8	895	1.4
1950	2,768	5.3	1305	3.2	1009	2.3	909	2.0
2150	3,365	6.0	1440	3.6	1058	2.4	934	2.1
2250	3,685	6.3	1511	3.8	1086	2.5	948	2.1
2600	4,920	7.6	1770	4.7	1207	2.9	996	2.2
2800	5,707	8.3	1923	5.2	1297	3.2	1026	2.3
2700	8,338	9.6	1948	6.4	1382	4.2	1083	3.0
2100	7,948	8.6	1576	6.0	1206	4.2	1040	3.6
2500	11,264	10.6	1898	7.5	1428	5.3	1141	4.0
2750	13,360	12.0	2106	8.6	1589	6.1	1227	4.4
2000	14,141	10.7	1590	8.0	1274	6.1	1103	5.0
2700	25,772	15.6	2184	11.9	1747	9.0	1406	6.9
2100	26,596	14.2	1733	11.2	1433	8.8	1219	7.2
2400	34,738	16.8	1994	13.3	1649	10.5	1396	8.3
2600	40,768	18.5	2171	14.8	1801	11.7	1500	9.3
2700	43,964	19.4	2259	15.5	1877	12.3	1561	9.8
2850	48,984	20.8	2393	16.6	1991	13.3	1553	10.6
2950	52,483	21.7	2483	17.5	2071	13.9	1719	11.0
2000	31,333	15.0	1679	12.0	1413	9.7	1221	8.1
2600	65,606	28.3*	......	23.4*	......	......	......	......

armour.

SECTION IV.

RIGGING AND ROPES.

CHAPTER I.

THE rigging and ropes of a modern steamship still constitute a very important part of the vessel's equipment, notwithstanding the almost total abolition of sail area, and its extinction as a propelling agent in the present day steamer.

Generally too little attention is devoted to what are considered the minor details of a steamship's rigging, by those best qualified to determine the sizes of ropes and blocks, and the arrangement of tackles on a mechanical basis. The array of derricks around the masts and kingposts of a freighter, with their varying loads of from 2½ to 50 tons, exemplify the necessity for a closer acquaintance with the staying, guying and tackling of these appliances, to ensure that the whole of the system shall be designed throughout on an uniform basis.

RIGGING.

By the term "rigging" is generally denoted the *standing* rigging, or that part whose function is to stay or support the masts, spars and funnels, and comprises the shrouds, guys, pendants, bowsprit shrouds, jib-boom guys, stays and backstays. These supports are now invariably made of galvanized wire rope, either iron or mild steel, the latter being employed where strength and lightness are desired, or where heavy working derricks are fitted. A special quality called plough steel, is sometimes used when exceptionally great loads have to be lifted. Indeed, it will often be found cheaper to employ plough steel in these cases, as the number of shrouds or stays may thereby be reduced, thus effecting a greater saving in the quantity required than the extra cost in quality has involved.

Wire Rope.—As its name implies, wire rope is manufactured from small steel or iron wires, twisted into strands, six of which (usually) are laid up around a tarred hemp centre, the strands having a wire heart where strength is more important than flexi-

bility, otherwise where used as running gear and flexibility is a necessity they also have a hempen centre. The number of wires constituting a strand varies with the degree of flexibility required, 19 wires to a strand being ordinary flexible rope, and 37 wires extra flexible, such as would be used for derrick topping lifts. Steel wire rope for ship rigging should always be galvanized, otherwise it deteriorates rapidly, and where it is used for running gear, it should be soaked in boiling tallow and linseed oil, a process which will add much to its life.

Great care must be used at all times in handling it so as to avoid sharp nips or kinks, either of which is fatal. For this reason when used as hawsers, wire rope must be stowed on a reel having a core of suitable diameter, and in the case of running rigging, the proper diameter of sheave for a given size of wire is important. An undersized sheave shortens the life of the best rope, and by distorting the fibres, weakens its strength.

Approximate diameters of sheaves for extra flexible steel wire rope, are given in the table on page 381.

Splices. — Splices in wire rope, such as are necessary around thimbles and elsewhere, weaken its strength from 10 to 15 per cent. It is necessary, therefore, to take account of this in fixing on the safe working load. Likewise in ordering the lengths of rope, allowance must be made on net sizes for the number of splices worked.

Thimbles. — In working eyes in the ends of wire rope, it is necessary that the fibres forming the inside of eye should be protected from the destructive effect of a link or shackle pin bearing on same. To guard against this, the splice is worked around heart shaped eyes or thimbles. These, like the sheaves, must be of a suitable size for a given circumference of rope.

SHEAVES FOR EXTRA FLEXIBLE STEEL WIRE ROPE.

For Steering Leads, Topping Lifts and Purchases.

Circumference of Rope.	Diameter of Sheave.	Weight in Brass.*	Circumference of Rope.	Diameter of Sheave.	Weight in Brass.*
In.	In.	Lbs.	In.	In.	Lbs.
1	4½	2½	3½	16	46
1¼	6	5½	3¾	17	54
1½	7	8½	4	18	66
1¾	8	11	4¼	19	78
2	9	15	4½	20½	107
2¼	10½	20	4¾	21½	120
2½	12	26	5	23	138
2¾	13	29	5½	25	163
3	14	34	6	27	190
3¼	14½	37	6½	30	235

* Weight in cast iron = Brass × .85.

LENGTH OF WIRE ROPE REQUIRED FOR SPLICES.

Circumference of Rope.	Allowance for Iron Wire Rope.	Allowance for Steel Wire Rope.	Manila.
In.	In.	In.	
1	9	12	
1½	12	18	
2	15	21	
2½	18	24	An average allowance of 15 inches is made for Manila.
3	20	30	
3½	22	33	
4	24	36	
4½	27	39	
5	30	42	
6	35	48	
7	40	54	

GALVANIZED IRON AND STEEL WIRE RIGGING ROPES.

TO ADMIRALTY OR LLOYD'S REQUIREMENTS.

Sizes.		Weight per Fathom.	Breaking Stress.		
Circum.	Diameter.		Best Best Galvanized Iron.	Galvanized Mild Steel.	Galvanized Patent Steel.
Inches.	Inches.	Lbs.	Tons.	Tons	Tons.
1	.318	0.96	1.2	1.75	2.8
1⅛	.397	1.2	1.6	2.25	3.6
1¼	.397	1.5	1.87	3	4.5
1⅜	.437	1.8	2.25	3.25	5.4
1½	.477	2.1	2.62	4	6.3
1⅝	.517	2.5	3.12	5	7.5
1¾	.557	2.9	3.62	5.5	8.7
1⅞	.596	3.3	4.12	6	9.9
2	.636	3.8	4.7	7	11.4
2⅛	.676	4.3	5.3	8	12.9
2¼	.716	4.8	6.0	9	14.4
2⅜	.755	5.3	6.6	10	15.9
2½	.795	5.9	7.3	11	17.7
2⅝	.835	6.6	8.2	12	19.8
2¾	.875	7.1	8.8	13	21.3
2⅞	.915	7.8	9.7	14.5	23.4
3	.954	8.5	10.6	16	25.5
3⅛	.994	9.2	11.5	17.5	27.6
3¼	1.03	9.9	12.3	19	29.7
3⅜	1.07	10.7	13.3	20.5	32.1
3½	1.11	11.5	14.3	22	34.5
3⅝	1.15	12.3	15.3	24	36.9
3¾	1.19	13.2	16.5	26	39.6
3⅞	1.23	14.1	17.6	28	42.3
4	1.27	15.0	18.7	30	45.0
4⅛	1.31	16.0	20.0	32	48.0
4¼	1.35	17.0	21.2	34	51.0
4⅜	1.39	18.0	22.5	36	54.0
4½	1.43	19.0	23.7	38	57.0
4⅝	1.47	20.1	25.1	40	63.3
4¾	1.51	21.2	26.5	42	63.6
4⅞	1.55	22.4	28.0	44	67.2
5	1.59	23.5	29.3	48	70.5
5¼	1.67	26.0	32.5	53	78.0
5½	1.75	28.5	35.6	58	85.5
6	1.9	34.0	42.5	68	102.0

STANDARD HOISTING ROPE.—SWEDISH IRON.

(Roebling.)

Composed of 6 Strands and a Hemp Center, 19 Wires to the Strand.

Diameter in Inches.	Approx. Circum. in Inches.	Approx. Weight per Foot.	Approx. Strength in Tons of 2000 Lbs.	Proper Working Load in Tons of 2000 Lbs.	Diameter of Drum or Sheave in Feet Advised.
2 3/4	8 5/8	11.95	111	22.2	17
2 1/2	7 7/8	9.85	92	18.4	15
2 1/4	7 1/8	8.0	72	14.4	14
2	6 1/4	6.30	55	11.0	12
1 7/8	5 7/8	5.55	50	10.0	12
1 3/4	5 1/2	4.85	44	8.8	11
1 5/8	5	4.15	38	7.6	10
1 1/2	4 3/4	3.55	33	6.6	9
1 3/8	4 1/4	3.00	28	5.6	8 1/2
1 1/4	4	2.45	22.8	4.56	7 1/2
1 1/8	3 1/2	2.00	18.6	3.72	7
1	3	1.58	14.5	2.90	6
7/8	2 3/4	1.20	11.8	2.36	5 1/2
3/4	2 1/4	0.89	8.5	1.70	4 1/2
5/8	2	0.62	6.0	1.20	4
9/16	1 3/4	0.50	4.7	0.94	3 1/2
1/2	1 1/2	0.39	3.9	0.78	3
7/16	1 1/4	0.30	2.9	0.58	2 3/4
3/8	1 1/8	0.22	2.4	0.48	2 1/4
5/16	1	0.15	1.5	0.30	2
1/4	3/4	0.10	1.1	0.22	1 1/2
		Cast Steel.			
2 3/4	8 5/8	11.95	211	42.2	11
2 1/2	7 7/8	9.85	170	34.0	10
2 1/4	7 1/8	8.00	133	26.6	9
2	6 1/4	6.30	106	21.2	8
1 7/8	5 7/8	5.55	96	19.0	8
1 3/4	5 1/2	4.85	85	17.0	7
1 5/8	5	4.15	72	14.4	6 1/2
1 1/2	4 3/4	3.55	64	12.8	6
1 3/8	4 1/4	3.00	56	11.2	5 1/2
1 1/4	4	2.45	47	9.4	5
1 1/8	3 1/2	2.00	38	7.6	4 1/2
1	3	1.58	30	6.0	4
7/8	2 3/4	1.20	23	4.6	3 1/2
3/4	2 1/4	0.89	17.5	3.5	3
5/8	2	0.62	12.5	2.5	2 1/2
9/16	1 3/4	0.50	10.0	2.0	2 1/4
1/2	1 1/2	0.39	8.4	1.68	2
7/16	1 1/4	0.30	6.5	1.30	1 3/4
3/8	1 1/8	0.22	4.8	0.96	1 1/2
5/16	1	0.15	3.1	0.62	1 1/4
1/4	3/4	0.10	2.2	0.44	1

FLEXIBLE STEEL WIRE ROPES.

For Cranes, Cargo and Purchase Falls.

A.—Flexible. Sizes in In. Cir.	Diam.	Weight per Fathom.	Breaking Stress.	Min. Diam. of Sheave.	B.—Special Flexible. Sizes in Ins. Cir.	Diam.	Weight per Fathom.	Breaking Stress.	Min. Dia. of Sheave.	C.—Extra Special Flexible. Sizes in Ins. Cir.	Diam.	Weight per Fathom.	Breaking Stress.	Min. Dia. of Sheave.
		Lbs.	Tons.	In.			Lbs.	Tons.	Ins.			Lbs.	Tons.	Ins.
1	.318	.678	2.1	6.	1	.318	0.9	2.79	5.4	1	.318	.83	2.57	4.5
1¼	.397	1.06	3.28	7.15	1¼	.397	1.4	4.34	6.6	1¼	.397	1.3	4.03	5.7
1½	.477	1.53	4.74	8.8	1½	.477	2.0	6.2	7.8	1½	.477	1.9	5.89	6.9
1¾	.557	2.09	6.47	10.17	1¾	.557	2.7	8.37	9.3	1¾	.557	2.5	7.75	7.8
2	.636	2.7	8.37	11.5	2	.636	3.6	11.16	10.5	2	.636	3.4	10.54	9.0
2¼	.716	3.4	10.54	13.2	2¼	.716	4.5	13.95	12.0	2¼	.716	4.2	13.02	10.2
2½	.795	4.2	13.62	14.57	2½	.795	5.6	17.36	13.2	2½	.795	5.2	16.12	11.4
2¾	.875	5.1	15.81	15.95	2¾	.875	6.8	21.08	14.4	2¾	.875	6.3	19.53	12.6
3	.954	6.1	18.91	17.6	3	.954	8.1	25.11	15.9	3	.954	7.5	23.25	13.5
3¼	1.03	7.2	22.32	18.97	3¼	1.03	9.5	29.45	17.4	3¼	1.03	8.8	27.28	14.7
3½	1.11	8.3	25.73	20.35	3½	1.11	11.0	34.1	18.6	3½	1.11	10.2	31.62	15.9
3¾	1.19	9.5	29.45	22.6	3¾	1.19	12.6	39.06	19.8	3¾	1.19	11.7	36.27	17.1
4	1.27	10.9	33.79	23.35	4	1.27	14.4	44.64	21.0	4	1.27	13.3	41.23	18.0
4¼	1.35	12.2	37.82	24.75	4¼	1.35	16.2	50.42	22.5	4¼	1.35	15.1	46.81	19.2
4½	1.43	13.7	42.47	26.12	4½	1.43	18.2	56.42	23.7	4½	1.43	16.9	52.39	20.4
4¾	1.51	15.3	47.43	27.5	4¾	1.51	20.3	62.93	25.2	4¾	1.51	18.8	58.28	21.6
5	1.59	16.9	52.39	29.05	5	1.59	22.5	69.75	26.4	5	1.59	20.8	64.48	22.8
5½	1.75	20.5	63.55	31.9	5½	1.75	27.2	84.32	29.1	5½	1.75	25.2	78.12	25.0
6	1.9	24.4	75.64	34.92	6	1.9	32.4	100.44	31.8	6	1.9	30.0	93.0	27.3

TABLE OF MILD STEEL OPEN THIMBLES.

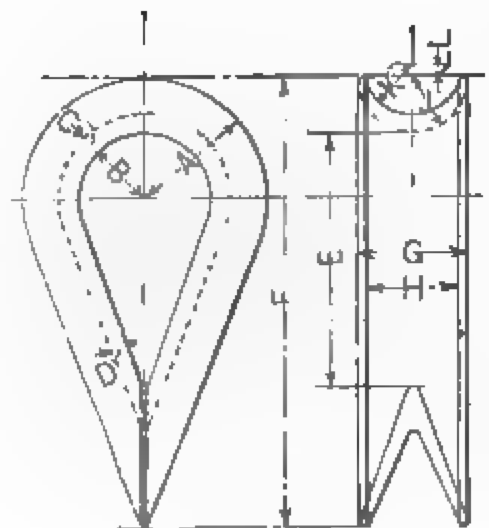
For Steel Wire Rope or Hawsers.

(British Admiralty.)

Circumference of Rope or Hawser.	Score.		Size in Clear.		Weight Each.
	Width.	Depth.	Width.	Length.	
In.	In.	In.	In.	In.	Lbs.
1	.4	.2	.87	1.50	$\frac{1}{4}$
$1\frac{1}{4}$ & $1\frac{1}{2}$	.6	.3	1.31	2.25	$\frac{9}{16}$
$1\frac{3}{4}$ & 2	.8	.4	1.75	3.00	$1\frac{7}{16}$
$2\frac{1}{4}$ & $2\frac{1}{2}$	1.0	.5	2.18	3.75	$2\frac{6}{16}$
$2\frac{3}{4}$ & 3	1.2	.6	2.62	4.50	$3\frac{14}{16}$
$3\frac{1}{2}$	1.4	.7	3.06	5.25	6
4	1.6	.8	3.50	6.00	9
$4\frac{1}{2}$	1.8	.9	3.93	6.75	$11\frac{1}{2}$
5	2.0	1.0	4.37	7.50	$16\frac{1}{2}$
$5\frac{1}{2}$	2.2	1.1	4.81	8.25	$23\frac{1}{2}$
6	2.4	1.2	5.25	9.00	$26\frac{1}{4}$
$6\frac{1}{2}$	2.6	1.3	5.68	9.75	$37\frac{1}{2}$
7	2.8	1.4	6.12	10.50	$44\frac{1}{2}$
8	3.2	1.6	7.00	12.00	$66\frac{1}{2}$

STANDARD WROUGHT IRON THIMBLES.

Wrought Iron.



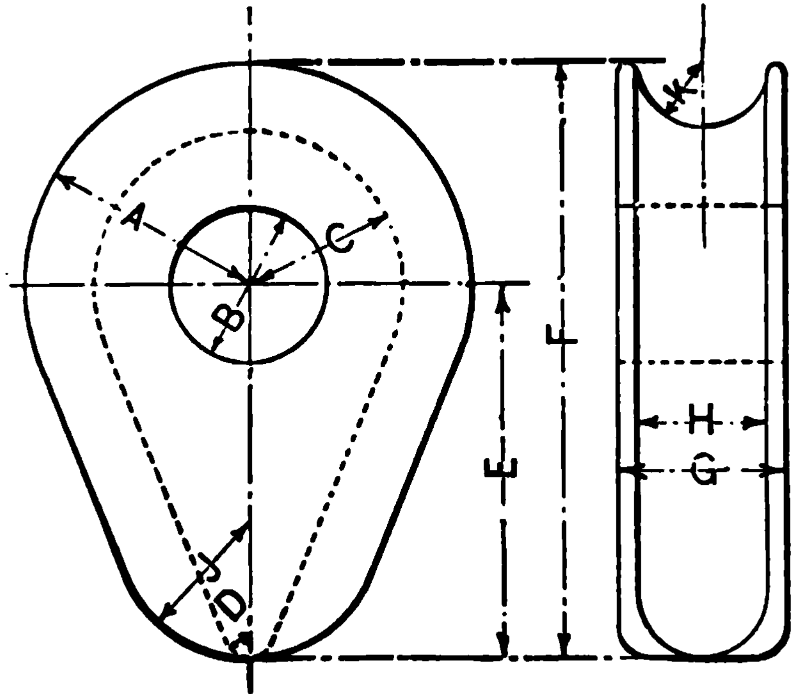
WROT IRON THIMBLE

FIG. 335.

Size of Rope	A.	B.	C.	D.	E	F.	G.	H.	J.	K.	L.
″	″	″	″	″	″	″	″	″	″	″	″
$1\frac{1}{4}$	$\frac{13}{16}$	$\frac{1}{2}$	$\frac{1}{8}$	$\frac{1}{8}$	$1\frac{5}{8}$	$2\frac{5}{8}$	$\frac{9}{16}$	$\frac{7}{16}$	$\frac{9}{32}$	$\frac{7}{32}$	$\frac{1}{16}$
$1\frac{1}{2}$	$1\frac{1}{32}$	$\frac{5}{8}$	$\frac{3}{16}$	$\frac{3}{16}$	$2\frac{1}{4}$	$3\frac{9}{16}$	$\frac{11}{16}$	$\frac{9}{16}$	$\frac{11}{32}$	$\frac{9}{32}$	$\frac{1}{16}$
$1\frac{3}{4}$	$1\frac{3}{16}$	$\frac{11}{16}$	$\frac{3}{16}$	$\frac{3}{16}$	$2\frac{5}{16}$	$3\frac{3}{4}$	$\frac{7}{8}$	$\frac{3}{4}$	$\frac{7}{16}$	$\frac{3}{8}$	$\frac{1}{16}$
2	$1\frac{5}{16}$	$\frac{3}{4}$	$\frac{3}{16}$	$\frac{3}{16}$	$2\frac{1}{2}$	$4\frac{3}{16}$	$1\frac{1}{16}$	$\frac{7}{8}$	$\frac{17}{32}$	$\frac{7}{16}$	$\frac{1}{16}$
$2\frac{1}{4}$–$2\frac{1}{2}$	$1\frac{7}{16}$	$\frac{13}{16}$	$\frac{3}{16}$	$\frac{3}{16}$	3	$6\frac{1}{8}$	$1\frac{3}{16}$	1	$\frac{19}{32}$	$\frac{1}{2}$	$\frac{1}{16}$
$2\frac{3}{4}$–3	$1\frac{5}{8}$	$\frac{7}{8}$	$\frac{1}{4}$	$\frac{3}{16}$	$3\frac{3}{8}$	6	$1\frac{7}{16}$	$1\frac{1}{4}$	$\frac{23}{32}$	$\frac{5}{8}$	$\frac{1}{16}$
$3\frac{1}{4}$–$3\frac{1}{2}$	$1\frac{7}{8}$	$1\frac{1}{16}$	$\frac{1}{4}$	$\frac{3}{16}$	$4\frac{1}{4}$	$7\frac{7}{16}$	$1\frac{5}{8}$	$1\frac{3}{8}$	$\frac{13}{16}$	$\frac{11}{16}$	$\frac{1}{8}$
$3\frac{3}{4}$–4	$2\frac{3}{16}$	$1\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{16}$	5	$8\frac{15}{16}$	$1\frac{15}{16}$	$1\frac{5}{8}$	$\frac{31}{32}$	$\frac{13}{16}$	$\frac{1}{8}$
$4\frac{1}{4}$–$4\frac{1}{2}$	$2\frac{9}{16}$	$1\frac{7}{16}$	$\frac{3}{8}$	$\frac{3}{16}$	$5\frac{3}{4}$	$10\frac{5}{16}$	$2\frac{1}{8}$	$1\frac{3}{4}$	$1\frac{1}{16}$	$\frac{7}{8}$	$\frac{1}{8}$
$4\frac{3}{4}$–5	$2\frac{7}{8}$	$1\frac{5}{8}$	$\frac{7}{16}$	$\frac{3}{16}$	$6\frac{1}{2}$	$11\frac{5}{16}$	$2\frac{1}{4}$	$1\frac{7}{8}$	$1\frac{1}{8}$	$\frac{15}{16}$	$\frac{1}{8}$

STANDARD CAST IRON THIMBLES.

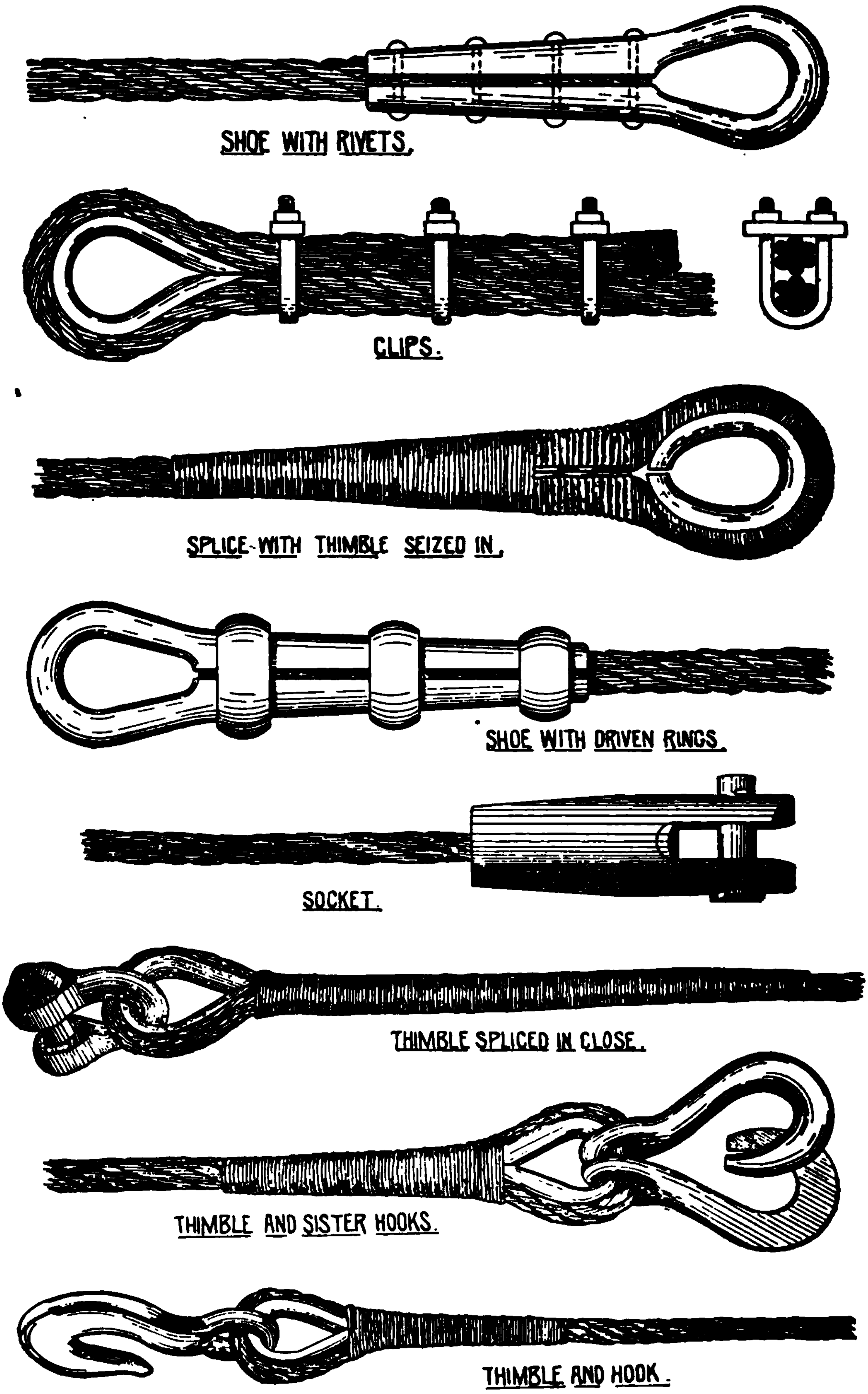
Cast Iron.



CAST IRON THIMBLE
FIG. 336.

Size of Rope.	A.	B.	C.	D.	E.	F.	G.	H.	J.	K.
"	"	"	"	"	"	"	"	"	"	"
1½	1⅛	$\frac{13}{16}$	¾	⅛	1¾	2⅞	⅞	⅝	⅝	$\frac{5}{16}$
1¾	$1\frac{5}{16}$	$\frac{15}{16}$	⅞	⅛	2	$3\frac{5}{16}$	1	¾	¾	⅜
2	1½	$1\frac{1}{16}$	$1\frac{1}{16}$	$\frac{3}{16}$	2⅜	3⅞	1⅛	⅞	⅞	$\frac{7}{16}$
2¼–2½	$1\frac{11}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$\frac{3}{16}$	2¾′	$4\frac{7}{16}$	1¼	1	1	½
2¾–3	2⅛	$1\frac{5}{16}$	1½	¼	3½	5⅝	1½	1¼	$1\frac{3}{16}$	⅝
3¼–3½	$2\frac{5}{16}$	$1\frac{9}{16}$	1⅝	¼	3⅞	$6\frac{3}{16}$	1¾	1⅜	1⅜	$\frac{11}{16}$
3¾–4	2¾	$1\frac{13}{16}$	$1\frac{15}{16}$	$\frac{5}{16}$	4½	7¼	2	1⅝	$1\frac{9}{16}$	$\frac{13}{16}$
4¼–4½	3	$2\frac{1}{16}$	2⅛	$\frac{5}{16}$	4⅞	7⅞	2⅛	1¾	1¾	⅞
4¾–5	$3\frac{3}{16}$	$2\frac{15}{16}$	2¼	⅜	5¼	$8\frac{7}{16}$	2¼	1⅞	1⅞	$\frac{15}{16}$

WIRE ROPE END-FITTINGS.



FIGS. 337–344.

Rope End Fittings.—Another method of forming an eye on the end of wire rope, is to work an open eye with groove-shaped ends, to enclose the rope, and through which they are riveted as shown in the plate. This "shoe," however, is rarely resorted to unless on the bowsprit shrouds, and similar rigging on yachts, where small close-fitting eyes are desired for neat appearance.

Some of the more common forms of wire rope end fittings are illustrated on the preceding page. Their various uses will suggest themselves to the observant.

Parcelling and Serving.—In ordinary merchant work, the lower ends of shrouds and stays for 6 or 7 feet are wormed and parcelled with two overlapping layers of cotton sheeting, painted and thereafter served. Where stays are subjected to much chafing, they should be doubly served and covered with leather in the collars.

No serving must be fitted on stays which carry sails, as it would only be cut to pieces by the chafe of the hanks.

Turnbuckles.—Standing rigging is invariably set up with turnbuckles, or rigging screws to enable the wire to be tautened, as quite an appreciable amount of "stretch" takes place, more particularly in new rope.

These screws are proportioned to the breaking strength of the wire, which should be *spliced* around a solid heart-shaped core for the heavier sizes, or an open thimble in the case of light wire. Where used for shrouds, the lower end must be arranged to swivel freely, and the pad-eye riveted to sheerstrake, the connection developing the same strength as the screw. Where, however, they are set up fore and aft on stays, the pad should have a shackle-eye for pin, as 'thwartship movement is not then desirable, and the shackle-eye will permit of a smaller diameter pin being used.

In proportioning screws under one inch in diameter, an allowance of about 20 per cent must be added to the area of metal at root of thread, as compensation for the loss of strength sustained in cutting the screw. Screws should be smeared with tallow and coated with a canvas cover.

Sheerpoles.—It is usual to fit a rod to the heads of turnbuckles to shrouds connecting and supporting the heads in their relative position, and preventing the screws from slacking back. In small vessels it may be from $\frac{3}{4}''$ to $\frac{5}{8}''$ diameter, seized to each head with seizing wire. Where heavy rigging is dealt with, the sheerpole is bolted through the heart of turnbuckle, and bosses jumped on to form receptacles for belay pins.

Ratlines—Are commonly made of hemp or wire rope, seized at outer shrouds and passing around the others in a clove hitch,

and spaced about 24 inches apart. Rope, however, is being fast displaced by iron rod ratlines, seized with wire to shrouds.

ROPES.

Manila and hemp, tarred and white, are the materials from which most ship's ropes are made. As its name indicates, "Manila" hails from the Philippines, and is made from the fibre of the wild banana. Hemp rope is made from the fibre of the hemp plant, the Russian variety being most generally used. Tow lines are sometimes made of coir, which is manufactured from the tough fibrous husk of the cocoanut. In referring to ropes, the *circumference* always denotes the size.

Manila. — All running ropes and those used for sundry work on shipboard are made of Manila, as hemp, though stronger when white, is not pliable enough. It is usual to make it of 3 strands, although 4-stranded or shroud-laid rope is also made; and for yacht work, 4-strand Manila is best, as it is smaller in diameter for a given strength, besides being neater.

Manila is of greater strength than tarred hemp, and stands the weather much better than the untarred or white hemp, although not so strong as the latter.

The following tables give strengths and weights of Manila, hemp, and coir ropes: —

TRENGTH AND WEIGHT OF RIGGING CHAIN.

(B B B QUALITY.)

SIZE.	* WORKING LOAD F. S. 4 IN POUNDS.	† BREAKING STRESS IN POUNDS.	WEIGHT PER FOOT IN POUNDS.
$\frac{3}{16}$	675	2,700	.5
$\frac{1}{4}$	1,260	5,040	.75
$\frac{5}{16}$	1,876	7,504	1.08
$\frac{3}{8}$	2,660	10,640	1.50
$\frac{7}{16}$	3,640	14,560	2.00
$\frac{1}{2}$	4,620	18,480	2.67
$\frac{9}{16}$	5,740	22,960	3.33
$\frac{5}{8}$	6,860	27,440	4.17
$\frac{11}{16}$	8,120	32,480	5.17
$\frac{3}{4}$	9,800	39,200	6.18
$\frac{13}{16}$	11,200	44,800	7.00
$\frac{7}{8}$	12,460	49,840	8.00
$\frac{15}{16}$	14,280	57,120	8.85
1	15,960	63,840	10.00
$1\frac{1}{16}$	17,640	70,560	12.00
$1\frac{1}{8}$	19,320	77,280	15.00
$1\frac{1}{4}$	23,940	95,760	17.50
$1\frac{1}{2}$	32,200	128,800	20.00
$1\frac{3}{4}$	44,520	178,080	26.70
2	58,520	234,080	36.70

B B quality = 20% less than table. † B quality = 30% less than table.

SIZE OF SHEAVES FOR IRON BLOCKS.

OF SHEAVE.	WIDTH OF GROOVE.	SIZE OF CHAIN.	DIAM. OF SHEAVE.	WIDTH OF GROOVE.	SIZE OF CHAIN.	DIAM. OF SHEAVE.	WIDTH OF GROOVE.	SIZE OF CHAIN.
″	″	″	″	″	″	″	″	″
$2\frac{1}{2}$	$\frac{3}{8}$	. . .	7	$1\frac{1}{4}$	$\frac{3}{8}$	13	$2\frac{9}{16}$	$\frac{11}{16}$
$3\frac{1}{2}$	$\frac{1}{2}$	. . .	8	$1\frac{1}{2}$	$\frac{7}{16}$	14	$2\frac{3}{4}$	$\frac{3}{4}$
4	$\frac{5}{8}$	. . .	9	$1\frac{3}{4}$	$\frac{1}{2}$	15	3	$\frac{13}{16}$
$4\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{16}$	10	2	$\frac{9}{16}$	16	$3\frac{1}{4}$	$\frac{7}{8}$
5	$\frac{7}{8}$	$\frac{1}{4}$	11	$2\frac{1}{4}$	$\frac{5}{8}$	17	$3\frac{1}{2}$	$\frac{15}{16}$
6	1	$\frac{5}{16}$	12	$2\frac{1}{2}$	$\frac{11}{16}$	18	$3\frac{3}{4}$	1

WEIGHT

Kind of Blocks.	Single, Double, or Treble.	Size.	Weight in Lbs.	Size.	Weight in Lbs.	Size.	Weight in Lbs.	Size.	Weight in Lbs.	Size.	Weight in Lbs.	Size.	Weight in Lbs.	Size.	Weight in Lbs.
		"		"		"		"		"		"		"	
Wood	*S*	4	½	5	1¼	6	2½	7	3	8	4½	9	5¾	10	6
Wood	*D*	4	1¼	5	2¼	6	4	7	5¾	8	7½	9	9	10	11
Wood	*T*	4	1¾	5	3¼	6	4½	7	6¾	8	10	9	11½	10	15
Wood	*S*	4	1½	5	2¾	6	4¼	7	6½	8	8½	9	10¾	10	14
Wood	*D*	4	2¼	5	3¾	6	6	7	9½	8	13	9	16	10	25
Wood	*T*	4	3½	5	5¾	6	9½	7	12¾	8	18	9	23¾	10	35
Wood	*S*	...	...	...	...	...	...	7	7½	8	9½	9	11¾	10	16
Wood	*D*	...	...	...	...	...	...	7	10	8	14½	9	19	10	29
Wood	*T*	...	...	...	...	...	...	7	14	8	20½	9	27	10	39
Cargo block	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Gin.	...	...	...	...	...	...	...	...	...	...	...	...	...	10	19
Gin	...	...	...	...	...	...	...	...	...	8	12	...	...	10	21
Iron block Wire rope	*S*	...	...	...	...	...	...	...	...	...	...	...	...	sheave 10	40
Iron block Wire rope	*D*	...	...	...	...	...	...	...	...	...	...	...	...	sheave 10	60
Iron block Wire rope	*T*	...	...	...	...	...	...	...	...	...	...	...	...	sheave 10	100
Wood snatch	...	...	...	...	...	...	...	...	...	...	...	...	...	10	22
Iron snatch.	...	...	...	...	...	...	...	...	...	...	...	...	...	10	26
Rope w. iron	*S*	...	...	...	...	6	7	7	9	8	10	...	...	10	22
Rope w. iron	*D*	...	...	...	...	6	12	7	13	8	18½	...	...	10	32
Rope w. iron	*T*	...	...	...	...	6	14	7	19	8	23	...	...	10	51

OF BLOCKS.

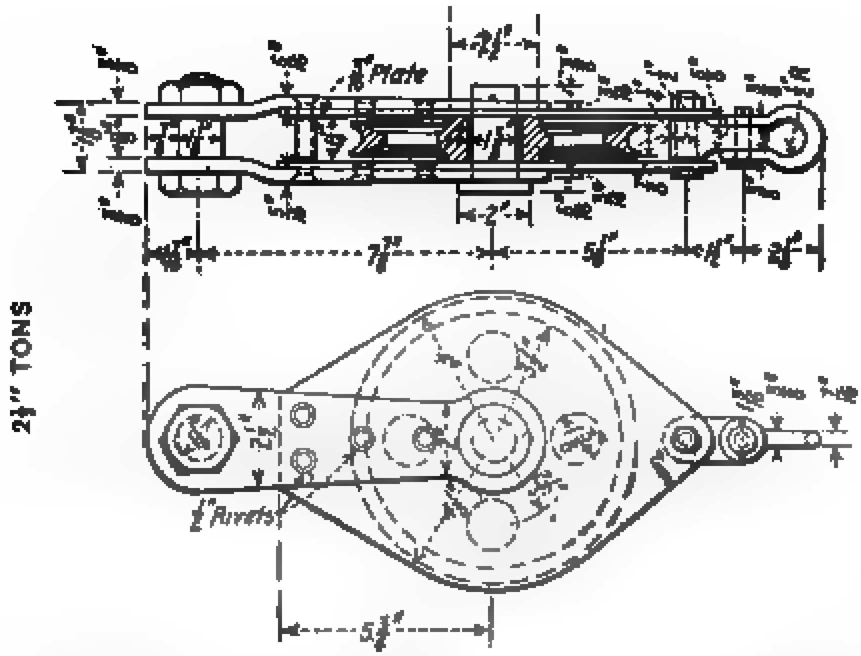
Size.	Weight in Lbs.	Size.	Weight in Lbs.	Size.	Weight in Lbs.	Size.	Weight in Lbs.	Size.	Weight in Lbs.	Size.	Weight in Lbs.	Size.	Weight in Lbs.	Size.	Weight in Lbs.
"		"		"		"		"		"		"		"	
..	...	12	11¾	..	..	14	20¼	..	..	..	..	..	..	..	...
..	...	12	20¼	..	..	14	35	..	..	..	..	..	...	..	...
..	...	12	28¾	..	..	14	49	..	...	..	..	..	...	..	...
11	20½	12	22	13	30	14	39	15	44	16	..	..	...	..	...
11	31	12	33	13	44	14	64	15	60	16	..	..	...	..	...
11	43	12	45	13	62	14	89	15	100	16	..	..	...	..	...
11	23	12	25	13	33	14	49	15	51	16	71	..	...	..	...
11	35	12	38	13	47	14	73	15	77	16	120	..	...	..	...
11	47	12	50	13	65	14	105	15	112	16	166	..	...	..	...
.	...	12	20	..	..	14	35	..	...	16	70	18	188	..	...
.	...	12	23	.	..	14	28	.	..	16	52	18	83	20	130
.	...	12	25½	..	..	......	..	15	35	..	..	18	100	..	...
.	...	sheave 12	67		..	sheave 14	89	.	..	..	..	..	...	..	...
..	...	sheave 12	109	.	..	sheave 14	150	..	...	..	..	..	...	..	...
.	..	sheave 12	145	..	..	sheave 14	210	.	...	..	..	..	...	..	...
..	...	12	33	..	..	14	46	..	...	16	66	18	90	20	140
..	.. .	12	41	..	..	14	56	..	...	16	86	18	106	20	147
..	.	r2	31	..	..	14	54	15	60	16	80	18	150	..	...
..	...	12	58	..	..	14	100	15	96	16	135	18	201	.	...
..	...	12	81	..	..	14	134	15	150	16	210	18	...	..	...

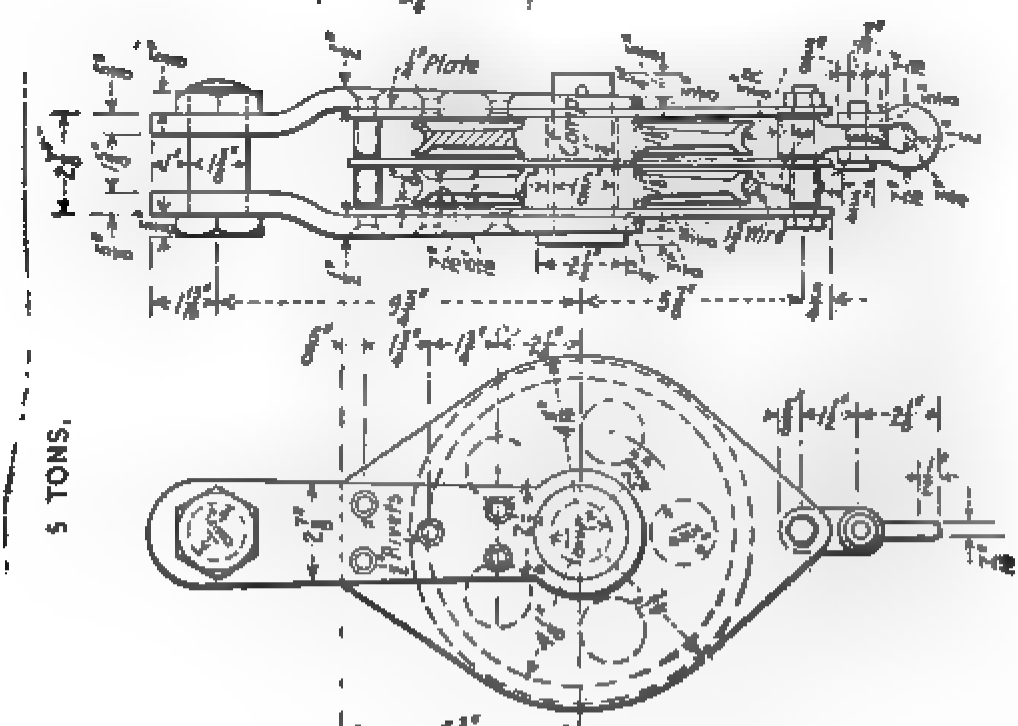
STANDARD BLOCKS OF U. S. NAVY.

Size and Type.	Length of Block.	Breadth of Block.	Thickness of: Sides.	Thickness of: Bridge.	Thickness of: Mortise.	Thickness of: Sheave.	Diameter of: Sheave.	Diameter of: Pin.	Diameter of: Hook.	Thickness of Mortise.*	Thickness of Sheave.*	Ultimate Strength in Lbs.
"	"	"	"	"	"	"	"	"	"	"	"	
4 S	4	3	[illegible]		[illegible]	[illegible]	2¼	[illegible]	[illegible]	[illegible]	[illegible]	1,750
4 D	4	3	[illegible]	½	[illegible]	[illegible]	2¼	[illegible]	[illegible]	[illegible]	[illegible]	3,500
5 S	5¼	3½	1		[illegible]	[illegible]	3	[illegible]	[illegible]	[illegible]	[illegible]	1,600
5 D	5¼	3½	1	[illegible]	[illegible]	[illegible]	3	[illegible]	[illegible]	[illegible]	[illegible]	3,200
6 S	6	4½	1⅛		1	[illegible]	3½	[illegible]	1	1 [illegible]	1	3,000
6 D	6	4½	1⅛	[illegible]	1	[illegible]	3½	[illegible]	1	1 [illegible]	1	6,000
7 S	7	5½	1 3/16		1 [illegible]	1	4¼	[illegible]	1 [illegible]	1 [illegible]	1 [illegible]	3,000
7 D	7	5½	1 3/16	[illegible]	1 [illegible]	1	4¼	[illegible]	1 [illegible]	1 [illegible]	1 [illegible]	6,000
8 S	8	6½	1¼		1 [illegible]	1 [illegible]	5	[illegible]	1 [illegible]	1 [illegible]	1 [illegible]	6,000
8 D	8	6½	1¼	1	1 [illegible]	1 [illegible]	5	[illegible]	1 [illegible]	1 [illegible]	1 [illegible]	12,000
9 S	9	7½	1 [illegible]		1 [illegible]	1 [illegible]	5½	[illegible]	1 [illegible]	1 [illegible]	1 [illegible]	9,000
9 D	9	7½	1 [illegible]	1	1 [illegible]	1 [illegible]	5½	[illegible]	1 [illegible]	1 [illegible]	1 [illegible]	18,000
10 S	10	8	1 [illegible]		1 [illegible]	1 [illegible]	6½	[illegible]	1 [illegible]	1 [illegible]	1 [illegible]	8,500
10 D	10	8	1 [illegible]	1 1/16	1 [illegible]	1 [illegible]	6½	[illegible]	1 [illegible]	1 [illegible]	1 [illegible]	17,000
11 S	11	9	1 [illegible]		1 [illegible]	1 [illegible]	7¼	[illegible]	1 [illegible]	1 [illegible]	1 [illegible]	9,000
11 D	11	9	1 [illegible]	1¼	1 [illegible]	1 [illegible]	7¼	[illegible]	1 [illegible]	1 [illegible]	1 [illegible]	18,000
12 S	12	9½	1 [illegible]		1 [illegible]	1 [illegible]	8	[illegible]	1 [illegible]	1 [illegible]	1 [illegible]	15,000
12 D	12	9½	1 [illegible]	1½	1 [illegible]	1 [illegible]	8	[illegible]	1 [illegible]	1 [illegible]	1 [illegible]	30,000
13 S	13	10½	1 [illegible]		1 [illegible]	1 [illegible]	9	1	1 [illegible]	1 [illegible]	1 [illegible]	16,000
13 D	13	10½	1 [illegible]	1½	1 [illegible]	1 [illegible]	9	1	1 [illegible]	1 [illegible]	1 [illegible]	32,000
14 S	14	11½	2 1/16		1 [illegible]	1 [illegible]	9½	1	1 [illegible]	1 [illegible]	1 [illegible]	15,000
14 D	14	11½	2 1/16	1½	1 [illegible]	1 [illegible]	9½	1	1 [illegible]	1 [illegible]	1 [illegible]	30,000
5 Sn	5	3½	1 [illegible]		1 [illegible]	1	3½	[illegible]	1	1 [illegible]	1 [illegible]	3,000
6 Sn	6	5	1½		1 [illegible]	1 [illegible]	4	[illegible]	1 [illegible]	1 [illegible]	1 [illegible]	5,500
7 Sn	7	5½	1 [illegible]		1 [illegible]	1 [illegible]	4½	[illegible]	1 [illegible]	1 [illegible]	1 [illegible]	5,300
8 Sn	8	6½	1 [illegible]		1 [illegible]	1 [illegible]	5½	[illegible]	1 [illegible]	1 [illegible]	1 [illegible]	8,500
9 Sn	9	7½	1 [illegible]	....	1 [illegible]	1 [illegible]	6½	[illegible]	1 [illegible]	1 [illegible]	1 [illegible]	12,200
10 Sn	10	8½	1 [illegible]	....	1 [illegible]	1 [illegible]	7	[illegible]	1 [illegible]	1 [illegible]	1 [illegible]	11,200
11 Sn	11	9½	1 [illegible]	....	1 [illegible]	1 [illegible]	7½	[illegible]	1 [illegible]	1 [illegible]	1 [illegible]	10,500
12 Sn	12	10½	1 [illegible]	....	1 [illegible]	1 [illegible]	8½	1	1 [illegible]	2	1 [illegible]	14,500
13 Sn	13	11½	2	....	2	1 [illegible]	9½	1 [illegible]	2	2¼	2	18,500
14 Sn	14	12	2 1/8	....	2¼	2¼	10½	1 [illegible]	2¼	....	....	21,000
15 Sn	15	12½	2¼	....	2¼	2¼	10½	1 [illegible]	2¼	....	....	24,500

* Dimensions for extra thickness of sheave. S=Single. D=Double. Sn=Snatch.

CARGO BLOCKS.





Figs. 345, 346.

CHAPTER III.

TACKLES.

When ropes are reeved through blocks to multiply the power it is proposed to apply, the combined gear constitutes what is known as a **tackle**. The principle of the block and tackle is the distribution of weight in various points of support, the mechanical advantage derived depending entirely upon flexibility and tension of the rope, and the number of sheaves in the moving block, hence by tackles the power is to the weight as the number of parts attached to the moving block, therefore (1) divide the weight to be raised by the number of parts leading "to," "from," or "made fast" to the moving block, and the quotient is the power required to produce equilibrium — **omitting friction.**

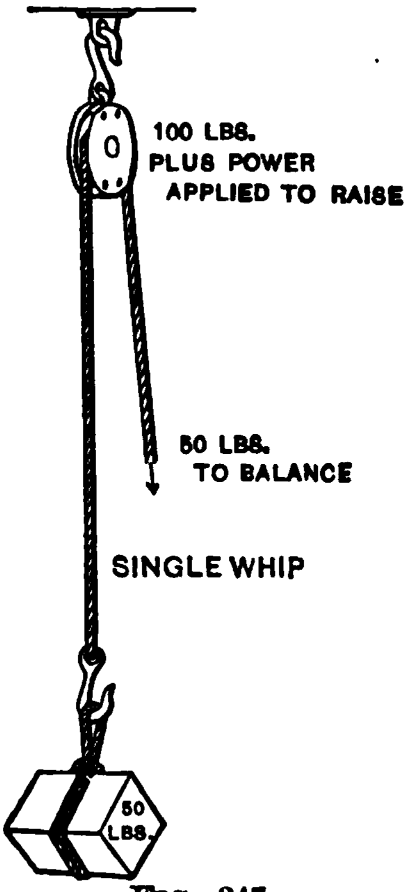


Fig. 347.

(2) Divide the weight to be raised by the power proposed, and the quotient is the number of sheaves in, or parts attached to, the moving block.

It should be noted that the upper block of a tackle has to bear the weight to be raised, and the power applied to lift it. No power is gained by increasing the diameter of the sheaves, but by doing so you decrease friction.

In arranging the blocks for a purchase, note that the hauling part, **where possible**, should lead from the moving block, as by so arranging, the power is increased.

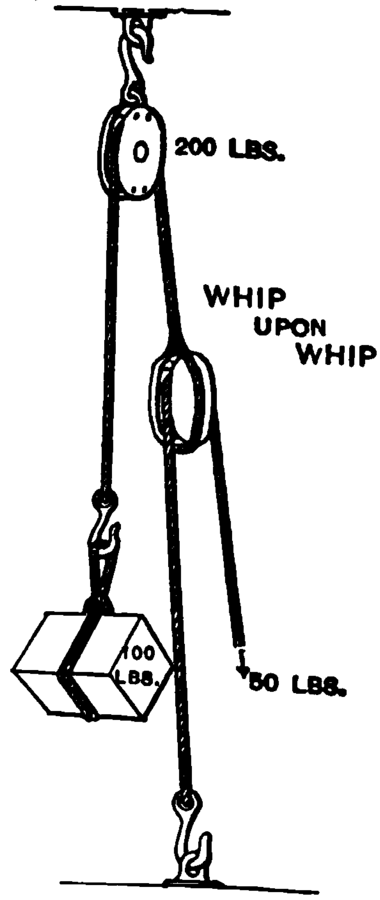


Fig. 348.

Tackles are named variously, sometimes as threefold, fourfold, etc., referring to the number of ropes rove; and as guy-tackles, sheet-tackles, etc., or by a distinctive name, whose derivation in most cases is obscure, like Spanish burton, etc.

A single whip and whip-upon-whip are shown by Figs. 272 *and 273 and their* mechanical advantage indicated.

trictly the single whip is not really a tackle, as no mechanical antage is gained. If we reverse the arrangement, and instead fixing the block, we make one end of the rope fast and haul on the other after it is rove through the block, which is now **movable**, we have a tackle with the power applied doubled.

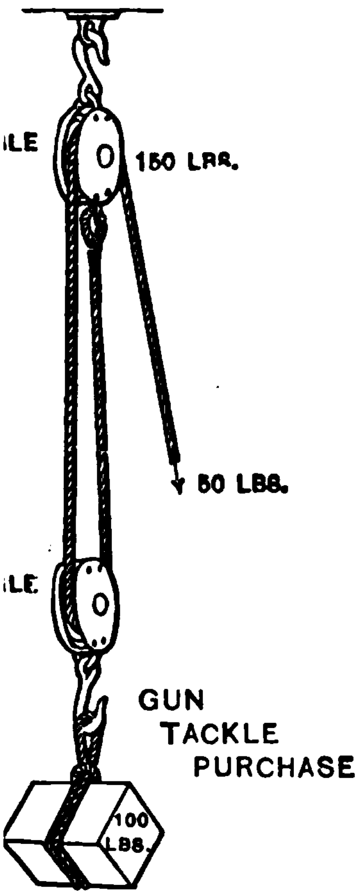


FIG. 349.

The next simplest form to the foregoing is the **gun-tackle purchase**, shown by Fig. 274, which consists of two single blocks, one movable and the other fixed. In the diagram, the power is shown as being applied to the fixed pulley, which results in doubling the power only. If, however, the order be reversed, and the rope becketed to the lower block, from which the hauling end would now lead, we should increase the power gained so that 150 lbs. could be sustained in equilibrium by the application of 50 lbs. In all tackles the hauled-on block has not only to support the load pendant on it, but also the power required to lift the load.

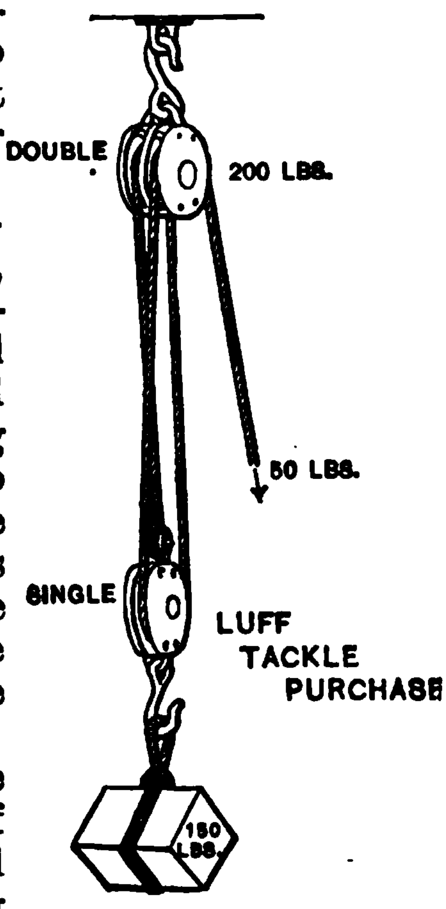


FIG. 350.

The **luff-tackle purchase** shown in Fig. 275, is also known as a watch-kle, and has exactly the same mechanical antages, although consisting of a double and gle block, as the gun-tackle with the hauling t taken from the movable block, that is to , the power applied equals one third of the ght to be raised. The case, however, is erent if the hauling rope of the luff-tackle taken from the movable block, when the o of power to weight is increased to one rter.

twofold purchase consists of two double ks, and has a ratio of power to weight of quarter, when hauled on from the fixed k, and of one fifth when from the moving k.

threefold purchase comprises a pair of treble blocks with echanical advantage of one sixth leading from the fixed block, one seventh when hauled on from the moving block.

ig. 276 shows a **single Spanish burton**, which is composed two single blocks with the tackle reeved as shown. This

purchase has the same power as the luff tackle, but less friction. It is a handy and powerful purchase, used for doing odd jobs.

The **double Spanish burton** is made up of a luff-tackle and a whip, with the standing parts toggled on together to the becket of the lower single block. It has the same power, but with much less friction, as a threefold purchase hauled on from the moving block.

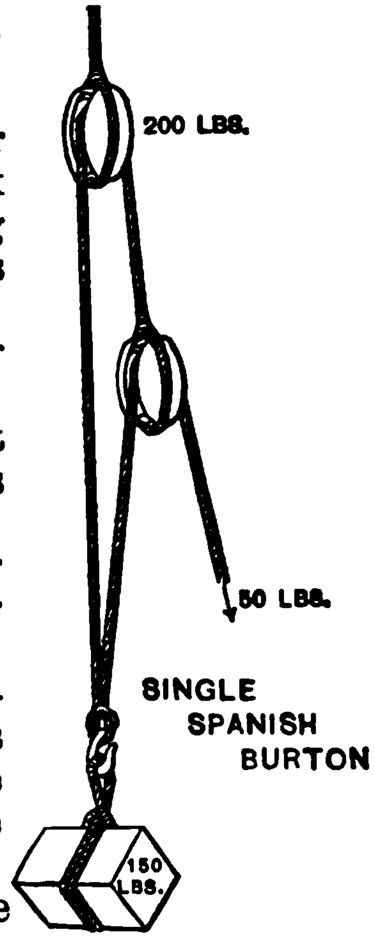


FIG. 351.

Relieving tackles are usually two or three-fold purchases, having the fixed block shackled on end of spare tiller, and the hauling block made fast on the quarter. These tackles are used for steering, in case of break-down, and need only to be figured for the steamer going at slightly over half speed.

A tackle may be attached to the hauling part of another tackle, and so multiply the powers of which they are comprised.

In arranging purchases the minimum number of sheaves for the power required should be used, and all superfluous fair-leads dispensed with, as each additional sheave fitted for that purpose absorbs power.

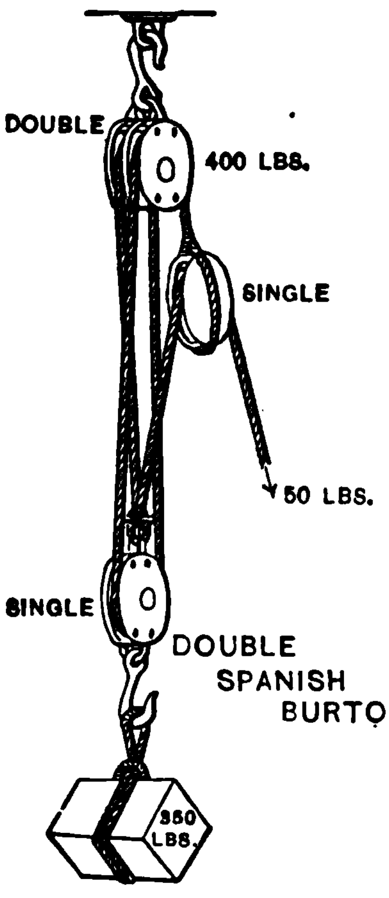


FIG. 352.

As an example of the application of the foregoing notes on purchases to the finding of a suitable tackle for a given load, let us take the case of relieving tackles on tiller. The twisting moment on the rudder head is first calculated by the rule given on page 106, which we shall assume to be 150,000 inch-lbs. With a spare tiller 50 inches long from centre of stock to shackle pin, we should have a net load of 3,000 lbs. to move, and it is proposed to use a four-fold purchase (*i.e.*, 2 double blocks) for the purpose, which will increase the load by four tenths (4 sheaves by one tenth of the load each for friction), making the actual load to be operated $3,000 + 1,200 = 4,200$ lbs. The moving block being on the tiller head, it is not practicable to haul from it, therefore we have only 4 parts at this block. Dividing the total load by *four ropes,* we get 1,050 lbs. (.47 ton) tension on each fall. With

a factor of safety of $4\frac{1}{2}$, using the best Manila rope, we get the equivalent circumference from the formula

$$\sqrt{\text{tension} \times 10} = \sqrt{.47 \times 10} = 2\tfrac{1}{8}'',$$

say $2\frac{1}{4}''$, as the manufactured sizes grade by quarters.

The size of the double blocks to take the rope would be 7 inches, obtained by the rule on p. 394, and it would require four men to handle the hauling part.

It is desired to lift a weight of 12 tons with a ship's derrick, and the maximum load on the winch must not exceed 5 tons; required the purchase, size of steel wire rope falls and blocks? Owing to the heavy load dealt with in this case, the factor of safety need not exceed 5. The hauling part of falls to be led through a leading block at heel of derrick.

Load to be raised	12	tons
Friction of 5 sheaves	6	"
Derrick gear	.4	"
Total load to overcome	18.4	"

As the load on the winch may not exceed 5 tons, the purchase should be $\dfrac{18.4}{4.6}$ = four parts in the falls — a twofold purchase.

A factor of safety of 5 having previously been decided upon, we get for the breaking stress $4.6 \times 5 = 23$ tons, and the equivalent circumference of special flexible steel wire rope, per table = 3 inches circ., which will require two double blocks with sheaves $13\frac{1}{2}$ inches in diameter. It should be noted that the maximum tension comes on the hauling part in hoisting, but on the standing part in lowering.

The stress on topping lift, allowing for friction of one sheave, and power applied is equal to 9.4 tons, requiring special flexible steel wire rope of $3\frac{1}{4}''$ circumference.

A fourfold purchase rove with Manila 4″ circ. having two 12″ double blocks, with wide mortise and the hauling part taken from the moving block, will be suitable for the load of 9.4 tons minus the power applied, *i.e.*, $8\frac{1}{4}$ tons.

The following tables give the strength of tackles and the breaking stress from actual test of hooks and shackles, fitted by the makers to the various sizes of blocks.

The proper working load for new Manila ropes is $\frac{1}{5}$ of the breaking stress. Of course, first grade Manila will develop a greater strength than what is shown by the accompanying tables of tackles, which are based on the strength of new rope adopted by the manufacturers, and consequently should be worked to when figuring the safe working load.

Rule to find the equivalent circumference of Manila rope for a given working load or tension (in tons) on one part of a fall, based on a factor of safety of 8:—

Circumference $= \sqrt{10 \times \text{tension}}$ which is very easily memorized.

Inversely, the safe working load for a given circumference of Manila will be

$$\frac{\text{Circ}^2}{10} = \text{safe load.}$$

STRENGTH OF TACKLES

Ordinary Blocks.

Size of Block.	Circ. of Manila.	Two Single Blocks.		Two Double Blocks.		Two Treble Blocks.	
		Breaking Stress of Hooks in Lbs.	Breaking Stress of Rope in Lbs.	Breaking Stress of Hooks in Lbs.	Breaking Stress of Rope in Lbs.	Breaking Stress of Hooks in Lbs.	Breaking Stress of Rope in Lbs.
"	"						
3	1	1,143	1,400	1,492	2,800	2,219	4,200
3½	1¼	1,492	1,800	2,218	3,600	2,985	5,400
4	1½	2,218	3,600	2,985	7,200	3,987	10,800
5	2	2,985	6,400	3,987	12,800	5,410	18,200
6	2½	3,987	8,100	5,410	16,200	6,360	24,300
7	2¾	5,410	12,100	6,360	24,200	9,356	36,300
8	3	6,360	14,400	9,356	28,800	13,720	43,200
9	3	9,356	14,400	13,720	28,800	16,030	43,200
10	3½	13,720	19,600	16,030	39,200	18,722	58,800
12	[illegible]	16,030	22,500	18,722	45,000	20,375	67,500
14	4½	18,722	28,900	20,375	57,800	28,300	86,700
16	5	20,375	40,000 Twofold	28,300	80,000 Fourfold	35,680	120,000 Sixfold

STRENGTH OF TACKLES.

Wide Mortise and Heavy Tackle.

Size of Block.	Circumference of Manila.	Two Single Blocks.		Two Double Blocks.		Two Treble Blocks.	
		Breaking Stress of Hooks in Lbs.	Breaking Stress of Rope in Lbs.	Breaking Stress of Hooks in Lbs.	Breaking Stress of Rope in Lbs.	Breaking Stress of Hooks in Lbs.	Breaking Stress of Rope in Lbs.
"	"						
7	3	6,360	14,400	9,350	28,800	13,720	43,200
8	3½	9,356	19,600	13,720	39,200	16,030	58,800
9	3½	13,720	19,600	16,030	39,200	18,722	58,800
10	4	16,030	22,500	19,050	45,000	19,050	67,500
12	4¾	19,050	32,400	20,375	64,800	28,300	97,200
14	5½	28,300	43,300	35,680	86,600	35,680	129,900
16	6¼	35,680	48,400	72,100	96,800	72,100	145,200
			Twofold.		Fourfold.		Sixfold.

Wrecking Blocks and Lashing Shackles.

Size of Block.	Circumference of Manila.	Two Single Blocks.		Two Double Blocks.		Two Treble Blocks.	
		Breaking Stress of Shackles in Lbs.	Breaking Stress of Rope in Lbs.	Breaking Stress of Shackles in Lbs.	Breaking Stress of Rope in Lbs.	Breaking Stress of Shackles in Lbs.	Breaking Stress of Rope in Lbs.
"	"						
18	7	116,300	67,600	132,532	135,200	155,542	202,800
20	8	132,532	78,400	155,542	156,800	172,400	235,200
22	9½	155,542	115,600	172,400	231,200	235,620	346,800
24	11	172,400	192,000	235,620	384,000	265,995	576,000
			Twofold.		Fourfold.		Sixfold.

DERRICK

CAPACITY

ITEM.	$2\frac{1}{2}$ TONS.	5 TONS.
Falls	130′ of $2\frac{3}{4}''$ G.S.W.R., single whip, 170 lbs.	130′ of 3″ G.S.W.R., single whip, 220 lbs.
Topping Lift	65′ of 3″ G.S.W.R., single whip, 110 lbs.	65′ of $3\frac{1}{2}''$ G.S.W.R., single whip, 135 lbs.
Guys	60′ of $2\frac{1}{4}''$ G.I.W.R., 60 lbs.	60′ of $2\frac{1}{4}''$ G.I.W.R., 60 lbs.
Chain	8′ 0″ of $\frac{9}{16}''$ crane chain, 25 lbs.	8′ 0″ of $\frac{13}{16}''$ crane chain, 55 lbs.
Topping Lift Purchase . .	30 fathoms of 4″ Manila, 90 lbs.	40 fathoms of 4″ Manila, 120 lbs.
Guy Purchase	60 fathoms of 3″ Manila, 96 lbs.	60 fathoms of 3″ Manila, 96 lbs.
Fall Blocks	2 @ 50 lbs. = 100 lbs.	2 @ 60 lbs. = 120 lbs.
Topping Lift Blocks . . .	1 @ 60 lbs. = 60 lbs.	1 @ 70 lbs. = 70 lbs.
Purchase Blocks	6 @ 40 lbs. = 240 lbs.	6 @ 40 lbs. = 240 lbs.
Shackles, etc.	100 lbs.	150 lbs.
Total weight of gear for one boom, excluding wire rope-reels, forgings to mast or boom, gooseneck, etc.	1,051 lbs.	1,266 lbs.

RIGGING.

OF DERRICK.

10 TONS.	20 TONS.	50 TONS.
260′ of 3″ G.S.W.R., gun tackle, 435 lbs.	300′ of 4″ G.S.W.R., luff tackle, 765 lbs.	710′ of 3″ G.P.S.W.R. (plough steel), Mech. adv. of tackle 7 = 1,200 lbs.
120′ of 3⅛″ G.S.W.R., gun tackle, 250 lbs.	300′ of 3½″ G.S.W.R., tackle rove, 630 lbs.	540′ of 3″ G.P.S.W.R., Mech. adv. 6 = 910 lbs.
60′ of 2¾″ G.I.W.R., 80 lbs.	60′ of 3″ G.I.W.R., 100 lbs.	100′ @ 3½″ G.I.W.R., 210 lbs.
Shackles used.		
40 fathoms of 4″ Manila, 120 lbs.	40 fathoms of 4″ Manila, 120 lbs.	Direct to winch.
60 fathoms of 3″ Manila, 96 lbs.	60 fathoms of 3½″ Manila, 130 lbs.	100 fathoms of 3½″ Manila, 220 lbs.
3 @ 60 lbs. = 180 lbs.	1 @ 100 lbs., 2 @ 60 lbs. = 220 lbs.	1 @ 150 lbs., 1 @ 100 lbs., 2 @ 60 lbs. = 370 lbs.
2 @ 60 lbs. = 120 lbs.	2 @ 100 lbs. = 200 lbs.	1 @ 50 lbs., 2 @ 100 lbs., 1 @ 60 lbs. = 310 lbs.
6 @ 40 lbs. = 240 lbs.	6 @ 40 lbs. = 240 lbs.	4 @ 40 lbs. = 160 lbs.
200 lbs.	300 lbs.	800 lbs.
1,721 lbs.	2,705 lbs.	4,180 lbs.

SECTION V.

CHAPTER I.

EQUIPMENT.

IN a modern steamship the Equipment, as understood by the classification societies, comprises that part of a vessel's outfit which relates to the handling of the ship and the safety of her complement, and in Lloyd's Register is represented by the numeral "1" after the character. Under this heading are included, anchors, chains, hawsers, boats, steering gear, windlass, and the requirements of the Board of Trade Regulations or the United States Inspection Laws.

Lloyd's Equipment.

The equipment as regards anchors, chains, hawsers, warps, etc. is regulated by the number produced by the sum of the measurements in feet arising from the addition of the half-moulded breadth of the vessel at the middle of the length, the depth from the upper part of the keel to the top of the upper deck beams (with the normal camber), and the girth of the half midship frame section of the vessel, measured from the centre line at the top of the keel to the upper deck stringer plate, multiplied by the length of the vessel for a one, two, and three decked vessel and for a spar decked vessel. For a vessel having a complete awning deck, or a continuous shade deck, the equipment number is to be increased one-eighth beyond that given by the measurements defined above to the main deck.

For a steam vessel with a partial awning deck, poop, top gallant forecastle, bridge house or a raised quarter deck the equipment number is to be increased beyond that for a flush or spar-decked vessel by that proportion of the addition made for a complete awning deck (*i.e.*, one-eighth) which the combined length of the erection bears to the length of the vessel. Where erections are fitted upon erections, the equipment number is to be correspondingly increased in the same proportion. (Sect. 39 of Lloyd's Rules.)

EQUIPMENT WEIGHTS (STEAMERS).

Per Lloyd's 1913–14 *Rules.*

Equipment Number.	Anchors.			Chain Cables.	Stream Chain.			Tow Line.			Hawser and Warp.		
	Bower Anchors, Collective Weights.		1 Stream 1 Kedge and Anchor, Collective Weights.		Stud Link, Short Link, or Steel Wire.			Hemp, Manila, or Steel Wire.			Hemp, Manila, or Steel Wire.		
				Stud Link.	Stud Link.	Short Link.	Steel Wire.	Hemp.	Manila.	Steel Wire.	Hemp.	Manila.	Steel Wire.
	No.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
* 2,400	2	980.00	174.72	3,262.56	728.00	812.00	.....	566.72	398.72	206.08	202.72	141.12	.....
3,000	2	1,176.00	245.28	3,870.72	896.00	979.00	123.20	675.36	473.76	281.12	360.64	253.12	.....
3,600	2	1,400.00	305.56	5,127.36	896.00	979.00	123.20	675.36	473.76	281.12	360.64	253.12	.....
4,200	2	1,596.00	420.00	7,207.20	1,091.00	1,176.00	169.12	791.84	555.52	281.12	360.64	253.12	.....
4,800	2	1,820.00	525.28	8,341.76	1,091.00	1,176.00	169.12	918.40	645.12	337.12	562.24	395.36	.....
5,400	2	2,016.00	594.72	9,424.80	1,223.04	1,335.04	247.52	1055.04	740.32	337.12	680.96	478.24	247.52
6,000	3	3,276.00	699.00	10,676.96	1,630.72	1,770.72	330.40	1055.04	740.32	337.12	680.96	478.24	247.42
6,700	3	3,976.00	805.72	14,140.00	1,935.36	2,103.36	330.40	1199.52	842.24	412.16	809.76	568.96	337.12
7,400	3	4,676.00	885.92	15,807.00	2,279.20	2,475.20	420.00	1354.08	950.88	412.16	809.76	568.96	337.12
8,100	3	5,376.00	979.00	18,816.00	2,279.20	2,475.20	420.00	1354.08	950.88	412.16	809.76	822.08	337.12
8,900	3	6,076.00	1,085.28	20,788.32	2,620.80	2,844.80	480.48	1822.24	1279.04	630.56	1170.40	964.13	337.12
9,700	3	6,776.00	1,190.56	22,753.92	2,620.80	2,844.80	480.48	1822.24	1279.04	630.56	1372.00	964.13	337.12
10,600	3	7,476.00	1,260.00	25,908.80	3,032.96	3,256.96	539.84	2030.56	1424.64	720.16	1372.00	964.13	337.12
11,600	3	8,176.00	1,400.00	27,108.48	3,791.20	4,171.20	675.36	2250.08	1578.08	720.16	1372.00	964.13	337.12
12,700	3	8,960.00	1,540.00	33,451.04	4,284.00	4,620.00	787.36	2250.08	1578.08	720.16	1372.00	964.13	337.12
13,900	3	9,744.00	1,680.00	35,772.80	4,284.00	4,620.00	787.36	2250.08	1578.08	720.16	2744.00	1928.64	674.24
15,200	3	10,528.00	1,820.00	38,606.40	4,852.96	5,188.96	900.48	2722.72	1910.72	809.76	2744.00	1928.64	674.24
16,700	3	11,312.00	1,960.00	41,490.40	4,852.96	5,188.96	900.48	2722.72	1910.72	809.76	2744.00	1928.64	674.24
18,500	3	12,320.00	2,090.00	44,553.60	5,437.60	5.829.60	1012.48	3240.16	2272.48	1079.68	3823.68	2685.76	1485.16
20,600	3	13,394.00	2,274.72	47,628.00	5,437.60	5,829.60	1012.48	3599.68	2525.60	1199.52	3823.68	2685.76	1485.16

* Read 2,400 and under 3,000; 3,000 and under 3,600, etc.

EQUIPMENT WEIGHTS (STEAMERS). — (*Continued.*)

Per Lloyd's 1913–14 *Rules.*

22,700	3	14,392.00	2,450.56	57,274.56	6,526.54	6,974.24	1215.20	3599.68	2525.60	1199.52	3823.68	2685.76	1485.16
25,000	3	15,568.00	2,625.28	60,340.00	7,295.68	7,799.68	1349.60	4319.84	3030.72	1440.32	4408.32	3095.68	1621.76
27,300	3	16,744.00	2,800.00	64,246.56	7,295.68	7,799.68	1349.60	5070.24	3557.12	1799.84	4408.32	3095.68	1621.76
29,700	3	17,920.00	3,010.56	68,166.56	7,295.68	7,799.68	1349.60	5070.24	3557.12	1799.84	4408.32	3095.68	1621.76
32,200	3	19,096.00	3,254.72	72,324.00	8,064.00	8,624.00	1710.24	5880.00	4126.20	2280.32	5084.80	3570.56	1800.96
34,800	3	20,444.00	3,500.00	76,423.20	8,064.00	8,624.00	1710.24	5880.00	4126.20	2820.16	5084.80	3570.56	1800.96
37,600	3	21,784.00	3,780.00	80,728.48	8,908.48	9,524.48	2114.56	6750.24	4736.48	3090.08	5084.80	3570.56	1800.96
40,400	3	23,184.00	4,130.56	94,556.00	11,878.72	12,690.72	2820.16	7312.48	5060.16	3640.00	6401.92	4493.44	2199.68
43,200	3	24,584.00	4,480.00	99,712.48	11,878.72	12,690.72	2820.16	7312.48	5060.16	3834.88	6401.92	4493.44	2199.68
46,000	3	25,984.00	4,830.56	105,280.00	13,002.08	13,898.08	3090.08	8320.48	5838.66	4029.76	6401.92	4493.44	2199.68
48,800	3	27,384.00	5,180.00	110,768.00	13,002.08	13,898.08	3090.08	8320.48	5838.66	4029.76	6401.92	4493.44	2199.68
51,600	3	28,840.00	5,530.56	128,016.00	14,196.00	15,176.00	3360.00	8320.48	5838.66	4029.76	6401.92	4493.44	2199.68
54,600	3	30,352.00	5,880.00	134,400.00	15,484.00	16,408.00	3720.64	9352.00	6574.40	5330.08	6401.92	4493.44	2199.68
57,600	3	31,920.00	6,230.56	140,890.00	15,484.00	16,408.00	3720.64	.....	.....	5330.08	7678.72	5389.44	2638.72
60,600	3	33,376.00	6,580.00	147,504.00	16,716.00	17,808.00	3720.64	.....	.....	5330.08	7678.72	5389.44	2638.72
63,800	3	34,832.00	6,930.56	154,360.00	17,892.00	19,208.00	3720.64	.....	.....	5330.08	7678.72	5389.44	2638.72
67,000	3	36,288.00	7,280.00	161,280.00	24,136.00	25,928.00	5400.64	.....	.....	6581.12	9598.40	6736.80	3298.40
70,200	3	37,632.00	7,630.06	168,336.00	25,928.00	27,944.00	5400.64	.....	.....	6581.12	9598.40	6736.80	3298.40
73,400	3	39,088.00	8,014.72	175,676.00	26,832.00	30,072.00	5400.64	.....	.....	6581.12	9598.40	6736.80	3298.40
76,800	3	40,544.00	8,400.00	183,008.00	26,832.00	30,072.00	5400.64	.....	.....	6581.12	11,518.08	8084.16	3958.08
80,200	3	42,112.00	8,673.28	190,512.00	29,764.00	32,256.00	6149.92	.....	.....	6581.12	11,518.08	8084.16	3958.08
83,800	3	43,680.00	9,170.56	198,128.00	29,764.00	32,256.00	6149.92	.....	.....	6581.12	11,518.08	8084.16	3958.08
87,600	3	45,248.00	9,554.72	205,968.00	31,808.00	34,608.00	6149.92	.....	.....	7950.88	11,518.08	8084.16	3958.08
91,600	3	47,040.00	9,940.00	213,920.00	31,808.00	34,608.00	6149.92	.....	.....	7950.88	11,518.08	8084.16	3958.08
95,800	3	48,832.00	10,325.28	222,096.00	33,516.00	36,960.00	7050.40	.....	.....	7950.88	11,518.08	8084.16	3958.08
100,200 & under 105,000	3	50,624.00	10,710.56	230,384.00	33,516.00	36,960.00	7050.40	.....	.....	7950.88	11,508.08	8084.16	3958.08

As an example of the method of applying the foregoing rule, let us take the case of a 3-deck vessel, having a complete shelter-deck, and a bridge superstructure with houses erected on it. This type will clearly exemplify all of the requirements of the rule, as we shall calculate the numeral firstly for a 3-deck vessel, to which we will then add one eighth for the complete shelter-deck, afterwards increasing it by the proportion that the length of bridge superstructure bears to the length of ship (or how much of another eighth we shall take), and finally resolving the *area* of the deck erections or superstructure into an equivalent length of vessel enclosing the same area, and adding its proportionate value.

Example: — Required the equipment numeral for a three-decked vessel having a complete shelter-deck on which is built a superstructure having deck houses on top: —

Dimensions:	$550' \times 65' \times 41'$ to shelter deck
	$33.5'$ to upper deck
Length of superstructure . .	$250'$
Size of deck houses	$100' \times 40'$
$= 4{,}000$ sq. ft. $= \frac{4000}{65} =$	$61.5'$ equivalent length
Half-breadth	$32.50'$
Depth (to U.DK+$16\frac{1}{4}''$ camber),	$34.85'$
Half girth	$63.00'$
	$130.35'$
Length	$\times 550'$
	71,692.5
Add $\frac{1}{8}$ for complete shelter deck	8,961.5
Add proportion of $\frac{1}{8}$ represented by $250'$ of superstructure	4,073.1
Add proportion of $\frac{1}{8}$ represented by $61.5'$ equivalent length of houses .	1,001.8
Equipment number . . .	85,728.9

The preceding "Table 22" of Lloyd's Rules shows the requirements of that Society for steam vessels based on the above rule.

AMERICAN SHIP WINDLASSES.

Lloyd's Equipment Numbers.	Size of Chain Cable.	Engines.	Steam Capstan Windlasses Weight in Lbs.	Steam Pump Brake Windlasses Weight in Lbs.
	" "	" "	Lbs.	Lbs.
6,150– 7,490	$\frac{15}{16}$ and 1	4 × 6	7,000	5,000
7,490– 9,770	$1\frac{1}{16}$ " $1\frac{1}{8}$	4 × 6	8,500	6,800
9,770–11,740	$1\frac{3}{16}$ " $1\frac{1}{4}$	5 × 7	9,000	7,300
11,740–13,450	$1\frac{5}{16}$ " $1\frac{3}{8}$	6 × 8	12,000	9,000
13,450–16,720	$1\frac{7}{16}$ " $1\frac{1}{2}$	7 × 8	13,000	12,250
16,720–19,780	$1\frac{9}{16}$ " $1\frac{5}{8}$	8 × 8	17,000	16,250
19,780–24,220	$1\frac{11}{16}$ " $1\frac{3}{4}$	9 × 8	17,850	17,100
24,220–30,020	$1\frac{13}{16}$ " $1\frac{7}{8}$	9 × 9	19,500	18,750
30,020–35,450	$1\frac{15}{16}$ " 2	10 × 10	27,000	24,000
35,450–43,600	$2\frac{1}{16}$ " $2\frac{1}{8}$	10 × 10	23,000	31,000
43,600–51,000	$2\frac{3}{16}$ " $2\frac{1}{4}$	12 × 12	31,000	33,000
51,000–59,000	$2\frac{3}{8}$ "	12 × 12	33,000	35,000

THE SHAW AND SPIEGLE PATENT AUTOMATIC STEAM TOWING MACHINE.

No. of Engine	Diameter of Hawser	Engine.	Weight of Machine in Lbs.	Diameter of Main Steam Pipe.	Diameter of Branch Steam Pipe.	Diameter of Main Exhaust Pipe.	Diameter of Branch Exhaust Pipe	To Tow Deadweight Cargo of.	Deck Space.
	"	' "		"	"	"	"	Tons.	' " ' "
0	1	8× 8	6,600	2	$1\frac{1}{2}$	$2\frac{1}{2}$	$1\frac{1}{2}$	1,000	5 0×5 0
1	$1\frac{1}{4}$	10×10	9,800	2	2	$2\frac{1}{2}$	2	2,500	5 2×5 8
2	$1\frac{1}{2}$	12×12	14.500	$2\frac{1}{2}$	$2\frac{1}{2}$	3	$2\frac{1}{2}$	4,500	6 0×6 0
3	$1\frac{3}{4}$	14×14	19,500	$2\frac{1}{2}$	$2\frac{1}{2}$	3	$2\frac{1}{2}$	6,000	. . . .
4	2	16×14	21,500	$2\frac{1}{2}$	$2\frac{1}{2}$	3	$2\frac{1}{2}$	7,000 to 8,000	. . . .
5	2	16×16	28,000	3	3	$3\frac{1}{2}$	3	15,000	. . . .

MOORING SWIVEL.

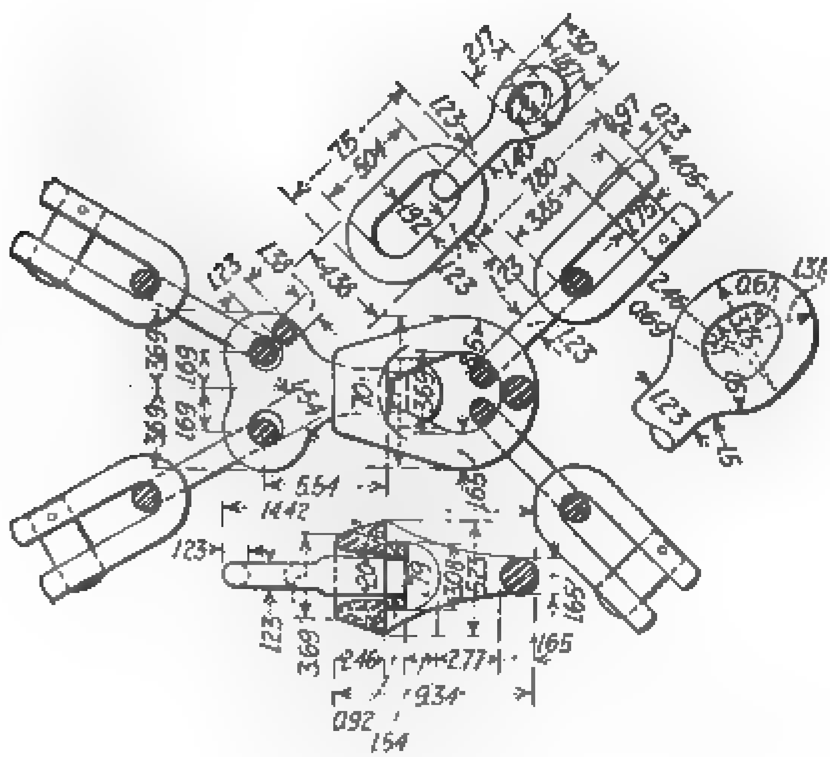


Fig. 353.

N.B. In all chain cable details the unit for determining the dimensions is the size of cable iron.

BLAKE STOPPER.

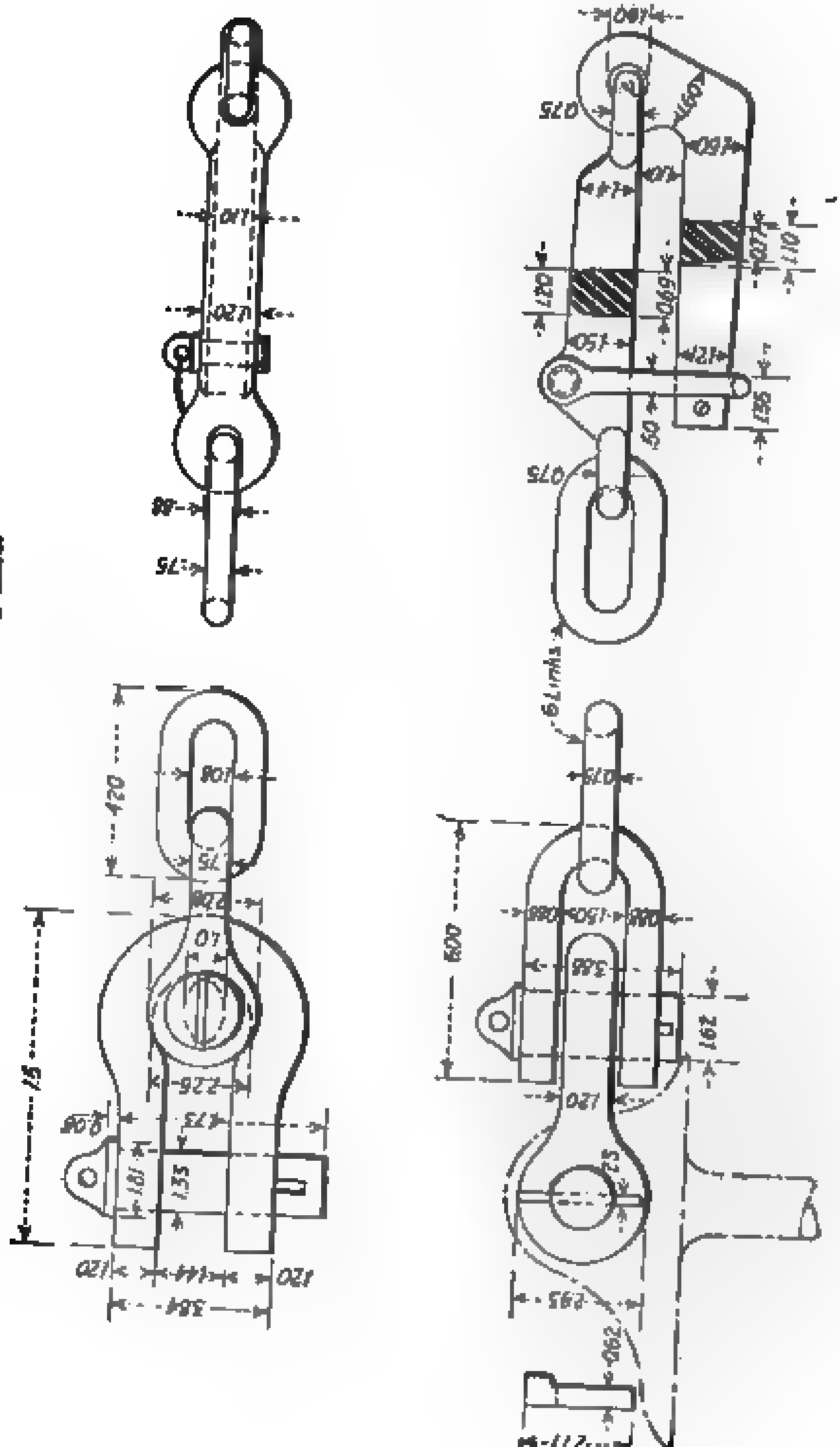


FIG. 384.

SENHOUSE SLIP.

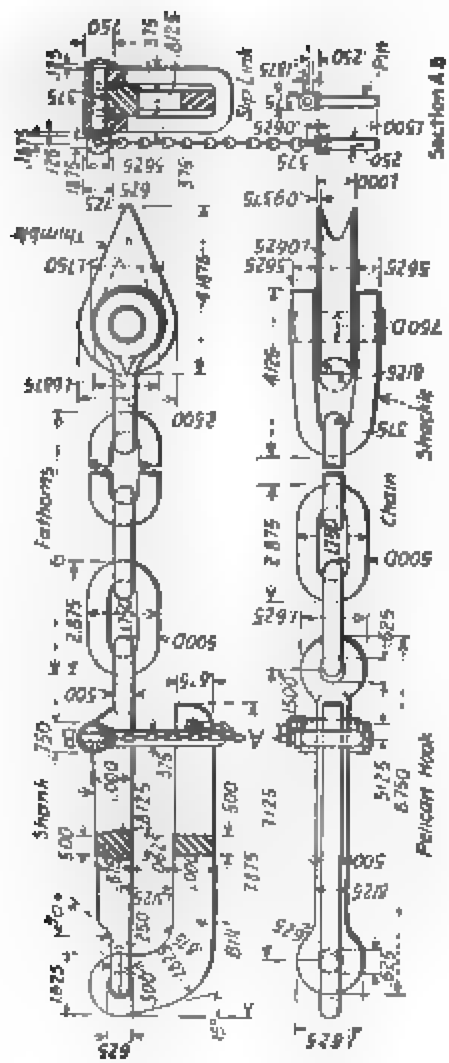


Fig. 255.

ADMIRALTY CABLE REQUIREMENTS.

Samples shall be taken by the Overseer indiscriminately for testing from every description of iron included in any one invoice, provided the number of bars, etc., so included does not exceed 50, and if above that number, one for every 50 or portion of 50 of each description. The samples may be tested to show the fibre, strength, ductility, and other qualities of the iron, and if not found satisfactory, the lot from which they are taken may be rejected.

In cases where the quantity of each size is small, and the total quantity of bars of all sizes does not exceed 50 No., one sample only need be tested, provided that all the bars represented thereby are supplied by one maker, and that the Overseer is satisfied as to the quality of the iron; the sample for testing shall be selected by him, and the acceptance or rejection of the batch shall depend upon the result of the tests.

The samples of every description of iron shall have an ultimate tensile strength respectively: —

Of not less than 23 tons to the square inch of section, for sizes under $2\frac{1}{4}$ inches;

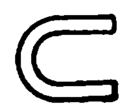
Of not less than $22\frac{1}{2}$ tons to the square inch of section, for sizes from $2\frac{1}{4}$ to $2\frac{9}{16}$ inches, both sizes inclusive; and

Of not less than 22 tons to the square inch of section, for sizes above $2\frac{9}{16}$ inches;

with an elongation of 20 per cent, in a length of 8 inches, for all sizes of iron.

Tensile tests, if not made on the premises of the Iron Manufacturer, shall be applied at a public testing house at the Contractors' expense, and in the presence of the Overseer.

Forge Test, Cold.

Every bar of 1-inch diameter and above shall admit of bending cold to the same radius as the end of the link for which it is to be used, thus: 

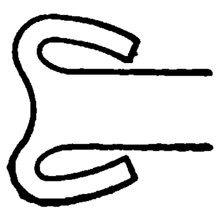
Bars under 1 inch to admit of bending cold, thus: 

A sample shall be notched and bent, thus: 
to show the fibre and quality of the iron, which is to be entirely satisfactory to the Overseer.

Forge Test, Hot.

Bars shall be punched with a punch one-third the diameter of the bar, at a distance of one and one-half diameters from the

end of the bar. The hole may then be drifted out to one and one-quarter times the diameter of the bar. The side of the hole may then be split, and the ends must admit of turning back without fracture, thus:



The whole of the articles, including the annealed crucible cast steel or forged steel stud pins of the cables, and the tinned steel pins, etc., shall be made only of material approved by the Overseer. The iron for the articles enumerated in Schedules II and III shall be also well hammered and rolled, and of quality approved by the Overseer.

Anchor shackle bolts shall be made of blooms at least twice worked, and not of bar iron. The square links and shackles, together with the swivels and bolts, shall be worked or drawn out under hammers of sufficient weight, and the welds or shuts shall be made in the most perfect and solid manner. No iron shall be used in which the brand-mark is so deeply cut as to unduly weaken the section, or is so situated as to make unsatisfactory work in forming the link, and the Contractors shall make arrangements for storing the Admiralty cable iron separately from all other cable iron.

All the stud pins of the chain cable shall be marked on one side with the name or initials of the Contractors, and on the other side with the date of the year of delivery into store. The several lengths of each chain cable, and mooring, pendant or bridle chain, and the joining shackles and large shackles to be connected therewith, shall be marked as follows, viz.: — The end links of the lengths of the cable with a distinguishing number, and the broad arrow; the joining shackles and anchor shackles with the same distinguishing number, the broad arrow, and the initials of the Contractors; the mooring and other swivels and splicing shackles, on their largest part, with a distinguishing number, the broad arrow, and the initials of the Contractors; and the splicing shackles and swivels with the date of the year of delivery into store, in addition. Cables and all cable gear will be received for the first four months of each year with the last year's date on the stud pins.

Tests. — The whole of the articles enumerated in Schedules I, II and III, shall be subjected, before delivery, to the proof strains prescribed in the Specification and Tables herewith, and to the following breaking test, which shall be first applied.

Chain Cables, Bridle and Pendant. — A sample of three links taken from each length of chain cable, or each bridle and pendant chain, shall be subject to tensile strain until it breaks. The links shall be cut out at the public testing machine in the presence of the Overseer, when practicable. Should it break under a less strain than 50 per cent in excess of the proof strain, the entire length of which that portion is a sample shall be rejected.

Cables and gear which pass the proving and breaking tests shall be minutely examined by the Overseer, and any flaws or defects which he may point out shall be remedied to his satisfaction before the cables and gear are forwarded to the yards.

The cables, etc., shall be cleaned sufficiently to permit of the Overseer guaranteeing the absence of flaws or defects.

TABLES OF DIMENSIONS, TESTS, ETC., FOR ADMIRALTY CHAIN CABLES.

Size of Cable, i.e., Diameter of Iron of Common Links.	Dimensions of Common Links Subject to the Latitude Stated in Clause 4 of the Specification.		Stay-Pin of Common Links: Weight of Each not to Exceed.	Weight of 100 Fathoms of Cable, with the Necessary Joining Shackles, etc., subject to the Latitude Stated in Clause 2 of the Specification			Weight of One Joining Shackle.	Weight of One End Link.	Weight of One Intermediate Link.	Weight of One Common Link.	Proof Strain to be Borne without Injury.
	Length (6 diams. of the iron).	Width (3.6 diams. of the iron).									
Ins.	Ins.	Ins.	Ozs.	Cwts.	Qrs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Tons.
3½	21	12 6	150 0	588	0	0	359	182 25	171 5	134	176.4
3¼	19½	11 7	119 8	507	0	0	287 5	145 9	137	107 25	161 6
3	18	10 8	94 5	432	0	0	226 1	114 75	108	84 38	145 8
2¾	16½	9 9	72 8	363	0	0	174	88 38	83	65	129 3
2 9/16	15⅜	9 2	58 9	315	0	21	140	71 5	66 3	52 6	118 2
2½	15	9 0	54 7	300	0	0	130	66 4	62 5	48 8	112½
2⅜	14¼	8 5	47 5	270	3	0	112	56 8	53 5	41 9	101½
2¼	13½	8 1	40	243	0	0	96	48 4	45 5	35 6	91⅛
2⅛	12¾	7 6	33 6	216	3	0	80	40 75	38 3	30	81¼
2	12	7 2	28	192	0	0	67	34	32	25	72
1⅞	11¼	6 7	23	168	3	0	55 25	28	26 33	20 6	63¼
1¾	10½	6 3	18 8	147	0	0	44 9	22 78	21 5	16 75	55⅛
1⅝	9¾	5 8	15	126	3	0	36	18 25	17 2	13.4	47½
1½	9	5 4	11 8	108	0	0	28	14 34	13 6	10 5	40½
1⅜	8¼	4 9	9	90	3	0	21 75	11	10 37	8 2	34
1¼	7½	4.5	6 9	75	0	0	16 31	8 32	7 75	6 1	28⅛
1⅛	6¾	4 0	5 0	63	3	4	11 87	6 10	5 7	4 5	22¾
1	6	3 6	3 5	52	3	6	8 37	4 25	4	3 2	18
⅞	5¼	3 1	2 4	40	1	20	5 61	2 84	2 66	2 2	13¾
¾	4½	2 7	1 5	29	2	2	3 53	1 70	1 68	1 4	10⅛
11/16	4⅛	2 5	1 14	24	3	23	2 72	1 37	1 29	1 1	8½
⅝	3¾	2 2	0 86	20	2	14	2 04	1 03	1 03	0 8	7
9/16	3⅜	2 0	0 62	16	2	23	1 40	0 75	0 702	0 58	5¾
½	3	1 8	0 44	13	0	22	1 04	0 53	0 47	0 41	4½
7/16	2⅝	1 6	0 30	10	0	12	0 7	0 34	0 33	0 28	3½
⅜	2¼	1 35	0 164	7	1	20	0 44	0 22	0 21	0.18	2 17/32

The breaking strain of the several sizes of cables shall not fall short of the above proof strains, with 50 per cent added.

NOTE. — The above proof strains are equivalent to the following strains per circular ⅛ inch of iron, viz., 3½ inch, 504 lbs.; 3¼ inch, 536 5 lbs.; 3 inch, 567 lbs.; 2¾ inch, 598.5 lbs.; 2 9/16 inch and under, 630 lbs. The table can be used for calculating the weight of cable in lengths less than 12½ fathoms.

ADMIRALTY CHAIN CABLES.

Common Links, *A*.			Second End Links, *B*.			Extreme End Links, *C*.		
Size of Iron, *F*.	Length Extreme, *G*.	Width Extreme, *H*.	Size of Iron, *I*.	Length Extreme, *J*.	Width Extreme, *K*.	Size of Iron, *L*.	Length Extreme, *M*.	Width Extreme, *N*.
Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
$3\frac{1}{4}$	$19\frac{1}{2}$	$11\frac{3}{4}$	$3\frac{1}{2}$	21	13	$3\frac{7}{8}$	22	13
$3\frac{3}{16}$	$19\frac{1}{8}$	$11\frac{1}{2}$	$3\frac{7}{16}$	$20\frac{5}{8}$	$12\frac{3}{4}$	$3\frac{13}{16}$	$21\frac{1}{2}$	$12\frac{3}{4}$
$3\frac{1}{8}$	$18\frac{3}{4}$	$11\frac{1}{4}$	$3\frac{3}{8}$	$20\frac{1}{4}$	$12\frac{1}{2}$	$3\frac{3}{4}$	21	$12\frac{1}{2}$
$3\frac{1}{16}$	$18\frac{3}{8}$	$11\frac{1}{8}$	$3\frac{5}{16}$	$19\frac{7}{8}$	$12\frac{1}{4}$	$3\frac{11}{16}$	$20\frac{5}{8}$	$12\frac{1}{4}$
3	18	$10\frac{7}{8}$	$3\frac{1}{4}$	$19\frac{1}{2}$	12	$3\frac{5}{8}$	$20\frac{1}{4}$	12
$2\frac{15}{16}$	$17\frac{5}{8}$	$10\frac{5}{8}$	$3\frac{3}{16}$	$19\frac{1}{8}$	$11\frac{3}{4}$	$3\frac{1}{2}$	$19\frac{3}{4}$	$11\frac{3}{4}$
$2\frac{7}{8}$	$17\frac{1}{4}$	$10\frac{3}{8}$	$3\frac{1}{8}$	$18\frac{5}{8}$	$11\frac{1}{2}$	$3\frac{3}{8}$	$19\frac{3}{8}$	$11\frac{1}{2}$
$2\frac{13}{16}$	$16\frac{7}{8}$	$10\frac{1}{8}$	$3\frac{1}{16}$	$18\frac{1}{4}$	$11\frac{1}{4}$	$3\frac{5}{16}$	19	$11\frac{1}{4}$
$2\frac{3}{4}$	$16\frac{1}{2}$	$9\frac{7}{8}$	3	$17\frac{3}{4}$	11	$3\frac{1}{4}$	$18\frac{1}{2}$	11
$2\frac{11}{16}$	$16\frac{1}{8}$	$9\frac{11}{16}$	$2\frac{15}{16}$	$17\frac{3}{8}$	$10\frac{3}{4}$	$3\frac{3}{16}$	$18\frac{1}{8}$	$10\frac{3}{4}$
$2\frac{5}{8}$	$15\frac{3}{4}$	$9\frac{1}{2}$	$2\frac{7}{8}$	17	$10\frac{1}{2}$	$3\frac{1}{8}$	$17\frac{5}{8}$	$10\frac{1}{2}$
$2\frac{9}{16}$	$15\frac{3}{8}$	$9\frac{1}{4}$	$2\frac{13}{16}$	$16\frac{5}{8}$	$10\frac{1}{4}$	$3\frac{1}{16}$	$17\frac{3}{8}$	$10\frac{1}{4}$
$2\frac{1}{2}$	15	9	$2\frac{3}{4}$	$16\frac{1}{4}$	10	3	$16\frac{7}{8}$	10
$2\frac{7}{16}$	$14\frac{5}{8}$	$8\frac{3}{4}$	$2\frac{11}{16}$	$15\frac{7}{8}$	$9\frac{3}{4}$	$2\frac{15}{16}$	$16\frac{7}{16}$	$9\frac{3}{4}$
$2\frac{3}{8}$	$14\frac{1}{4}$	$8\frac{9}{16}$	$2\frac{5}{8}$	$15\frac{7}{16}$	$9\frac{1}{2}$	$2\frac{7}{8}$	16	$9\frac{1}{2}$
$2\frac{5}{16}$	$13\frac{7}{8}$	$8\frac{5}{16}$	$2\frac{9}{16}$	15	$9\frac{1}{4}$	$2\frac{3}{4}$	$15\frac{5}{8}$	$9\frac{1}{4}$
$2\frac{1}{4}$	$13\frac{1}{2}$	$8\frac{1}{8}$	$2\frac{1}{2}$	$14\frac{5}{8}$	9	$2\frac{11}{16}$	$15\frac{3}{16}$	9
$2\frac{3}{16}$	$13\frac{1}{8}$	$7\frac{7}{8}$	$2\frac{3}{8}$	$14\frac{3}{16}$	$8\frac{3}{4}$	$2\frac{5}{8}$	$14\frac{3}{4}$	$8\frac{3}{4}$
$2\frac{1}{8}$	$12\frac{3}{4}$	$7\frac{11}{16}$	$2\frac{5}{16}$	$13\frac{3}{4}$	$8\frac{1}{2}$	$2\frac{9}{16}$	$14\frac{3}{8}$	$8\frac{1}{2}$
$2\frac{1}{16}$	$12\frac{3}{8}$	$7\frac{7}{16}$	$2\frac{3}{16}$	$13\frac{3}{8}$	$8\frac{1}{4}$	$2\frac{1}{2}$	$13\frac{5}{16}$	$8\frac{1}{4}$
2	12	$7\frac{3}{16}$	$2\frac{1}{8}$	13	8	$2\frac{7}{16}$	$13\frac{1}{2}$	8
$1\frac{15}{16}$	$11\frac{5}{8}$	7	$2\frac{1}{16}$	$12\frac{9}{16}$	$7\frac{3}{4}$	$2\frac{5}{16}$	13	$7\frac{3}{4}$
$1\frac{7}{8}$	$11\frac{1}{4}$	$6\frac{3}{4}$	2	$12\frac{1}{8}$	$7\frac{1}{2}$	$2\frac{1}{4}$	$12\frac{11}{16}$	$7\frac{1}{2}$
$1\frac{13}{16}$	$10\frac{7}{8}$	$6\frac{1}{2}$	$1\frac{15}{16}$	$11\frac{3}{4}$	$7\frac{1}{4}$	$2\frac{3}{16}$	$12\frac{3}{16}$	$7\frac{1}{4}$
$1\frac{3}{4}$	$10\frac{1}{2}$	$6\frac{5}{16}$	$1\frac{7}{8}$	$11\frac{3}{8}$	7	$2\frac{1}{8}$	$11\frac{13}{16}$	7
$1\frac{11}{16}$	$10\frac{1}{8}$	$6\frac{1}{16}$	$1\frac{13}{16}$	$10\frac{15}{16}$	$6\frac{3}{4}$	2	$11\frac{3}{8}$	$6\frac{3}{4}$
$1\frac{5}{8}$	$9\frac{3}{4}$	$5\frac{7}{8}$	$1\frac{3}{4}$	$10\frac{1}{2}$	$6\frac{1}{2}$	$1\frac{15}{16}$	11	$6\frac{1}{2}$
$1\frac{9}{16}$	$9\frac{3}{8}$	$5\frac{5}{8}$	$1\frac{11}{16}$	$10\frac{1}{8}$	$6\frac{1}{4}$	$1\frac{7}{8}$	$10\frac{1}{2}$	$6\frac{1}{4}$
$1\frac{1}{2}$	9	$5\frac{7}{16}$	$1\frac{5}{8}$	$9\frac{3}{4}$	6	$1\frac{13}{16}$	$10\frac{1}{8}$	6
$1\frac{7}{16}$	$8\frac{5}{8}$	$5\frac{3}{16}$	$1\frac{9}{16}$	$9\frac{5}{16}$	$5\frac{3}{4}$	$1\frac{11}{16}$	$9\frac{5}{8}$	$5\frac{3}{4}$
$1\frac{3}{8}$	$8\frac{1}{4}$	$4\frac{15}{16}$	$1\frac{1}{2}$	$8\frac{7}{8}$	$5\frac{1}{2}$	$1\frac{5}{8}$	$9\frac{1}{4}$	$5\frac{1}{2}$
$1\frac{5}{16}$	$7\frac{7}{8}$	$4\frac{3}{4}$	$1\frac{7}{16}$	$8\frac{1}{2}$	$5\frac{1}{4}$	$1\frac{1}{2}$	$8\frac{13}{16}$	$5\frac{1}{4}$
$1\frac{1}{4}$	$7\frac{1}{2}$	$4\frac{1}{2}$	$1\frac{3}{8}$	$8\frac{1}{8}$	5	$1\frac{7}{16}$	$8\frac{7}{16}$	5
$1\frac{3}{16}$	$7\frac{1}{8}$	$4\frac{1}{4}$	$1\frac{5}{16}$	$7\frac{11}{16}$	$4\frac{3}{4}$	$1\frac{3}{8}$	8	$4\frac{3}{4}$
$1\frac{1}{8}$	$6\frac{3}{4}$	$4\frac{1}{16}$	$1\frac{1}{4}$	$7\frac{1}{4}$	$4\frac{1}{2}$	$1\frac{5}{16}$	$7\frac{5}{8}$	$4\frac{1}{2}$
$1\frac{1}{16}$	$6\frac{3}{8}$	$3\frac{13}{16}$	$1\frac{3}{16}$	$6\frac{7}{8}$	$4\frac{1}{4}$	$1\frac{1}{4}$	$7\frac{1}{8}$	$4\frac{1}{4}$
1	6	$3\frac{5}{8}$	$1\frac{1}{8}$	$6\frac{1}{2}$	4	$1\frac{3}{16}$	$6\frac{3}{4}$	4
$\frac{15}{16}$	$5\frac{5}{8}$	$3\frac{3}{8}$	1	$6\frac{1}{16}$	$3\frac{3}{4}$	$1\frac{1}{8}$	$6\frac{1}{4}$	$3\frac{3}{4}$
$\frac{7}{8}$	$5\frac{1}{4}$	$3\frac{1}{8}$	$\frac{15}{16}$	$5\frac{5}{8}$	$3\frac{1}{2}$	$1\frac{1}{16}$	$5\frac{7}{8}$	$3\frac{1}{2}$
$\frac{13}{16}$	$4\frac{7}{8}$	$2\frac{15}{16}$	$\frac{7}{8}$	$5\frac{1}{4}$	$3\frac{1}{4}$	1	$5\frac{7}{16}$	$3\frac{1}{4}$
$\frac{3}{4}$	$4\frac{1}{2}$	$2\frac{11}{16}$	$\frac{13}{16}$	$4\frac{7}{8}$	3	$\frac{15}{16}$	5	3
$\frac{11}{16}$	$4\frac{1}{8}$	$2\frac{1}{2}$	$\frac{3}{4}$	$4\frac{1}{2}$	$2\frac{3}{4}$	$\frac{13}{16}$	$4\frac{5}{8}$	$2\frac{3}{4}$
$\frac{5}{8}$	$3\frac{3}{4}$	$2\frac{1}{4}$	$\frac{11}{16}$	4	$2\frac{1}{2}$	$\frac{3}{4}$	$4\frac{3}{16}$	$2\frac{1}{2}$
$\frac{9}{16}$	$3\frac{3}{8}$	$2\frac{1}{16}$	$\frac{5}{8}$	$3\frac{5}{8}$	$2\frac{1}{4}$	$\frac{11}{16}$	$3\frac{13}{16}$	$2\frac{1}{4}$
$\frac{1}{2}$	3	$1\frac{13}{16}$	$\frac{9}{16}$	$3\frac{1}{4}$	2	$\frac{5}{8}$	$3\frac{3}{8}$	2
$\frac{7}{16}$	$2\frac{5}{8}$	$1\frac{5}{16}$	$\frac{1}{2}$	$2\frac{13}{16}$	$1\frac{3}{4}$	$\frac{9}{16}$	$2\frac{15}{16}$	$1\frac{3}{4}$

CHAIN CABLE LINKS.

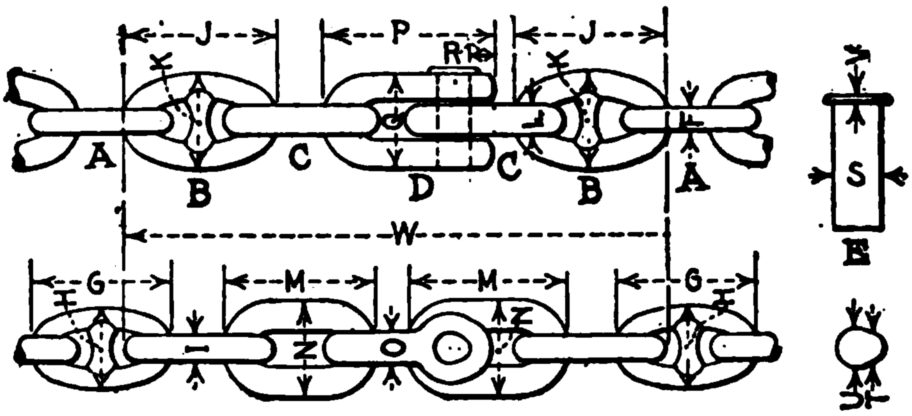


Fig. 356.

PROPORTIONS AND DETAILS OF LINKS AND SHACKLES.

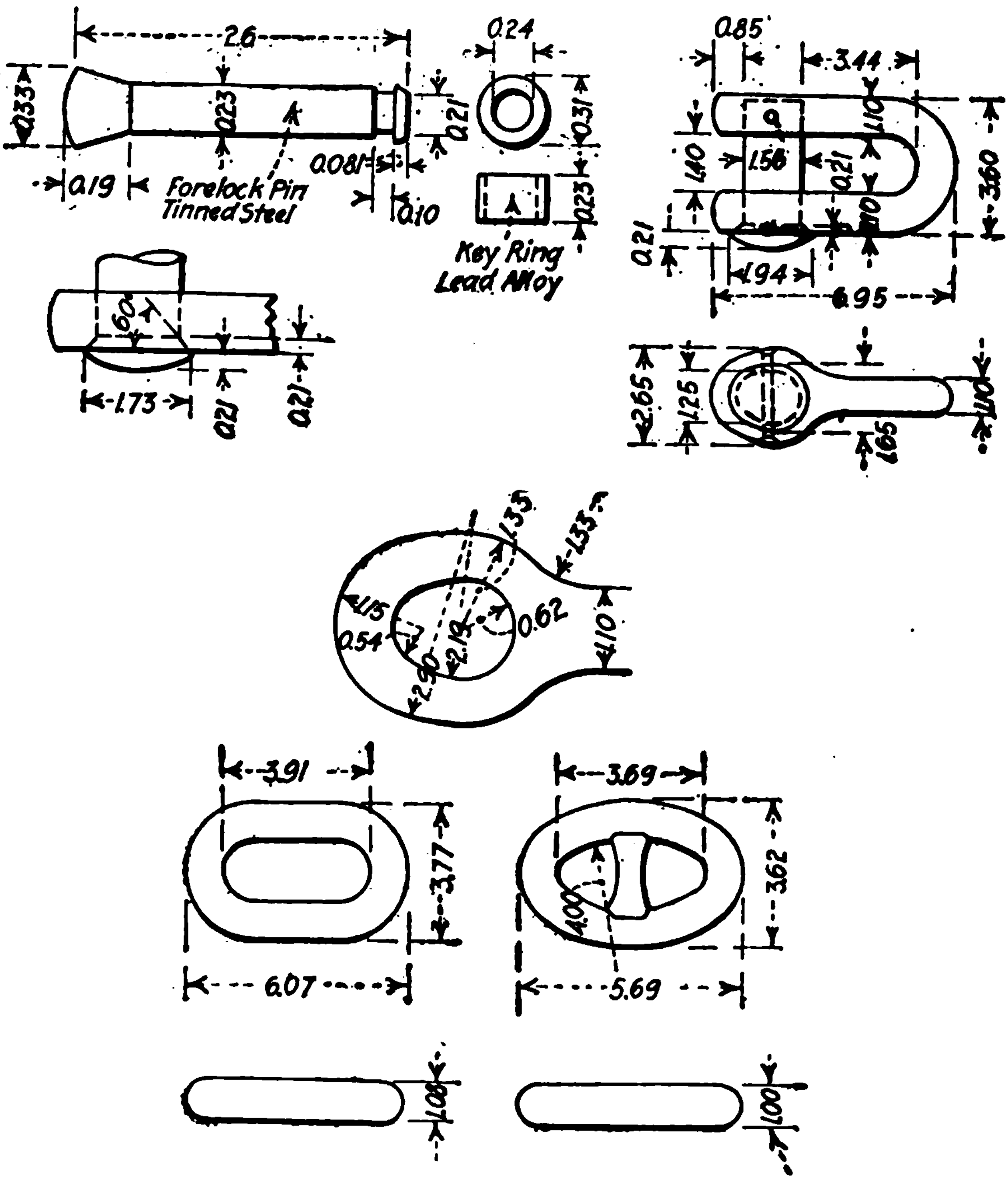


Fig. 357.

ADMIRALTY CHAIN CABLES.—(*Continued.*)

Shackles, D			Shackle Pins, E						
Size of Iron, O.	Length Extreme, P.	Width Extreme, Q.	R	S	T	U	V	W	
Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Feet	Ins.
4 1/2	23	13	2 11/16	5 3/8	3 1/2	3 7/8	5/8	6	2 5/16
4 5/16	22 5/8	12 5/8	2 5/8	5 1/4	3 5/16	3 13/16	5/8	6	0 13/16
4 1/8	22	12 3/8	2 9/16	5	3 1/4	3 3/4	5/8	5	11 3/16
4	21 5/8	12 1/8	2 1/2	4 7/8	3 3/16	3 11/16	5/8	5	9 5/8
3 7/8	21 1/8	12	2 7/16	4 13/16	3	3 5/8	5/8	5	8 3/8
3 13/16	20 5/8	11 5/8	2 3/8	4 11/16	2 15/16	3 9/16	5/8	5	7 1/8
3 3/4	20 1/4	11 3/8	2 5/16	4 9/16	2 7/8	3 1/2	5/8	5	5 5/8
3 5/8	20	11 1/8	2 1/4	4 1/2	2 13/16	3 3/8	5/8	5	4 3/8
3 9/16	19 5/8	11	2 3/16	4 7/16	2 3/4	3 5/16	5/8	5	2 13/16
3 1/2	19 1/8	10 5/8	2 1/8	4 5/16	2 11/16	3 3/16	5/8	5	1 7/16
3 3/8	18 5/8	10 3/8	2 1/16	4 1/4	2 5/8	3 1/8	5/8	4	11 13/16
3 5/16	18 1/4	10 1/8	2	4 1/8	2 9/16	3 1/16	5/8	4	10 13/16
3 1/4	17 3/4	10	2	4	2 1/2	3	5/8	4	9 5/8
3 3/16	17 5/16	9 5/8	1 15/16	3 7/8	2 7/16	2 15/16	5/8	4	7 13/16
3 1/16	16 7/8	9 3/8	1 7/8	3 13/16	2 3/8	2 7/8	5/8	4	6 1/8
3	16 7/16	9 1/8	1 7/8	3 11/16	2 5/16	2 3/4	9/16	4	5
2 15/16	16	9	1 13/16	3 5/8	2 1/4	2 11/16	9/16	4	3 3/8
2 7/8	15 5/8	8 5/8	1 3/4	3 1/2	2 3/16	2 5/8	9/16	4	2
2 3/4	15	8 3/8	1 11/16	3 3/8	2 1/8	2 9/16	9/16	4	0 5/16
2 11/16	14 5/8	8 1/8	1 5/8	3 5/16	2 1/16	2 1/2	9/16	3	11 5/8
2 5/8	14 3/16	8	1 5/8	3 3/16	2	2 7/16	1/2	3	9 7/8
2 1/2	13 13/16	7 5/8	1 9/16	3 1/8	1 15/16	2 5/16	1/2	3	8 1/8
2 7/16	13 3/8	7 3/8	1 1/2	3	1 7/8	2 1/4	1/2	3	6 1/16
2 3/8	12 7/8	7 1/8	1 7/16	2 7/8	1 13/16	2 3/16	1/2	3	5 7/16
2 1/4	12 7/16	7	1 3/8	2 13/16	1 3/4	2 1/8	1/2	3	4 3/8
2 3/16	11 13/16	6 5/8	1 3/8	2 11/16	1 11/16	2	7/16	3	2 13/16
2 1/8	11 3/8	6 3/8	1 5/16	2 5/8	1 5/8	1 15/16	7/16	3	1 7/16
2 1/16	11	6 1/8	1 1/4	2 1/2	1 9/16	1 7/8	7/16	2	11 9/16
1 15/16	10 5/8	6	1 3/16	2 3/8	1 1/2	1 13/16	7/16	2	10 3/8
1 7/8	10 1/8	5 5/8	1 1/8	2 5/16	1 7/16	1 11/16	7/16	2	8 13/16
1 3/4	9 5/8	5 3/8	1 1/16	2 3/16	1 3/8	1 5/8	3/8	2	7 3/8
1 11/16	9 3/16	5 1/8	1 1/16	2 1/8	1 5/16	1 9/16	3/8	2	6 5/16
1 9/16	8 3/4	5	1	2	1 1/4	1 1/2	3/8	2	4 13/16
1 1/2	8 5/16	4 5/8	15/16	1 7/8	1 3/16	1 7/16	3/8	2	3 5/8
1 7/16	7 13/16	4 3/8	7/8	1 13/16	1 1/8	1 5/16	3/8	2	1 13/16
1 3/8	7 3/8	4 1/8	13/16	1 11/16	1 1/16	1 1/4	5/16	2	0 3/8
1 5/16	7 1/8	4	13/16	1 5/8	1	1 3/16	5/16	1	10 5/8
1 3/16	6 5/8	3 3/4	3/4	1 1/2	15/16	1 1/8	5/16	1	9 3/16
1 1/16	6 3/16	3 1/2	11/16	1 3/8	7/8	1 1/16	5/16	1	7 13/16
1	5 5/8	3 1/4	5/8	1 5/16	13/16	1	5/16	1	6 7/16
15/16	5 3/16	3	5/8	1 3/16	3/4	15/16	1/4	1	4 13/16
7/8	4 3/4	2 3/4	9/16	1 1/8	11/16	13/16	1/4	1	3 3/8
13/16	4 5/16	2 1/2	1/2	1 1/16	5/8	3/4	1/4	1	2 1/16
3/4	4	2 1/4	7/16	15/16	9/16	11/16	1/4	1	0 5/8
11/16	3 9/16	2	7/16	13/16	1/2	5/8	1/4	0	11 1/8
9/16	3 1/8	1 3/4	3/8	11/16	7/16	9/16	1/4	0	9 5/8

CLUB SHACKLE

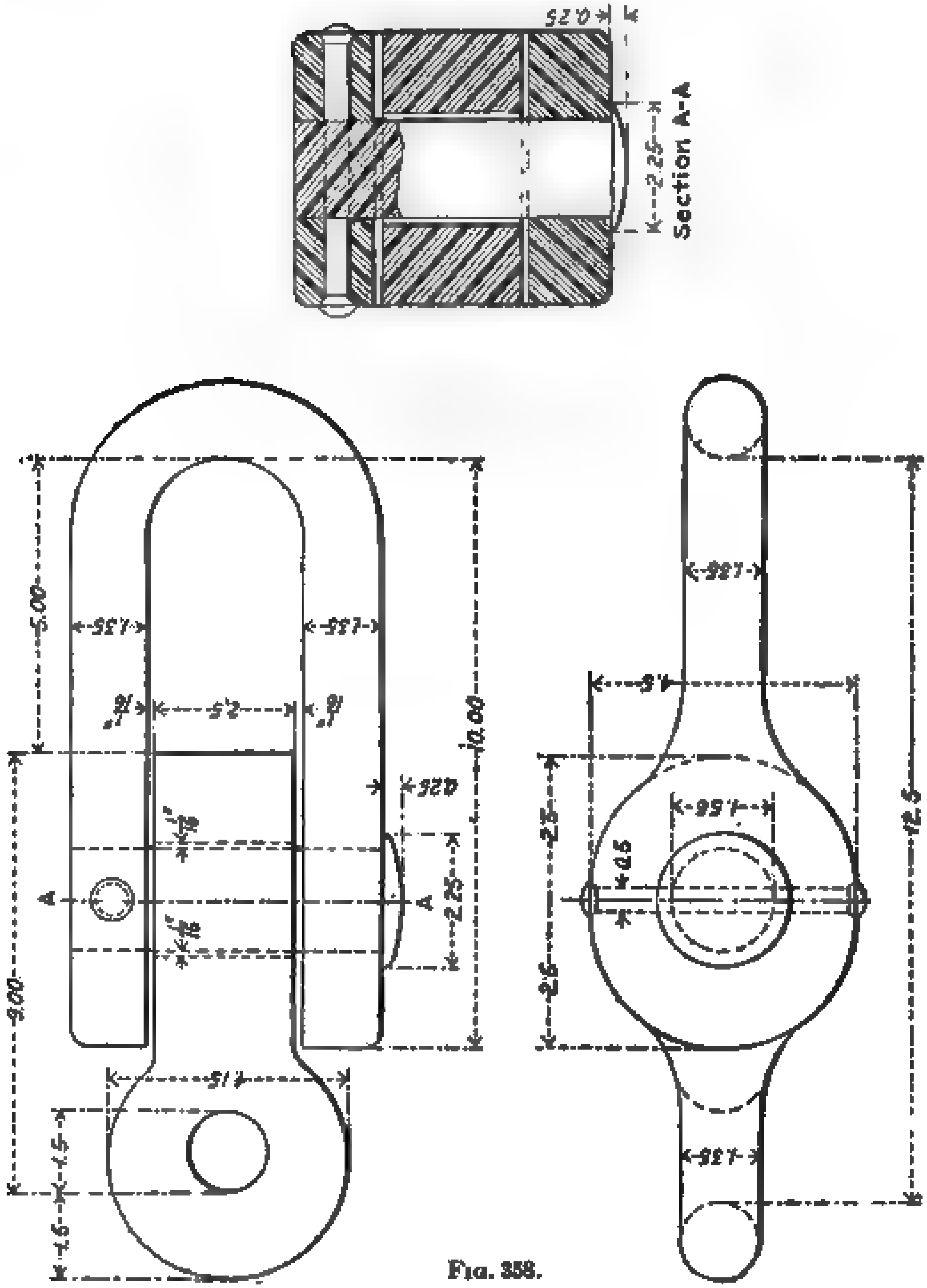


Fig. 358.

CHAIN SWIVEL.

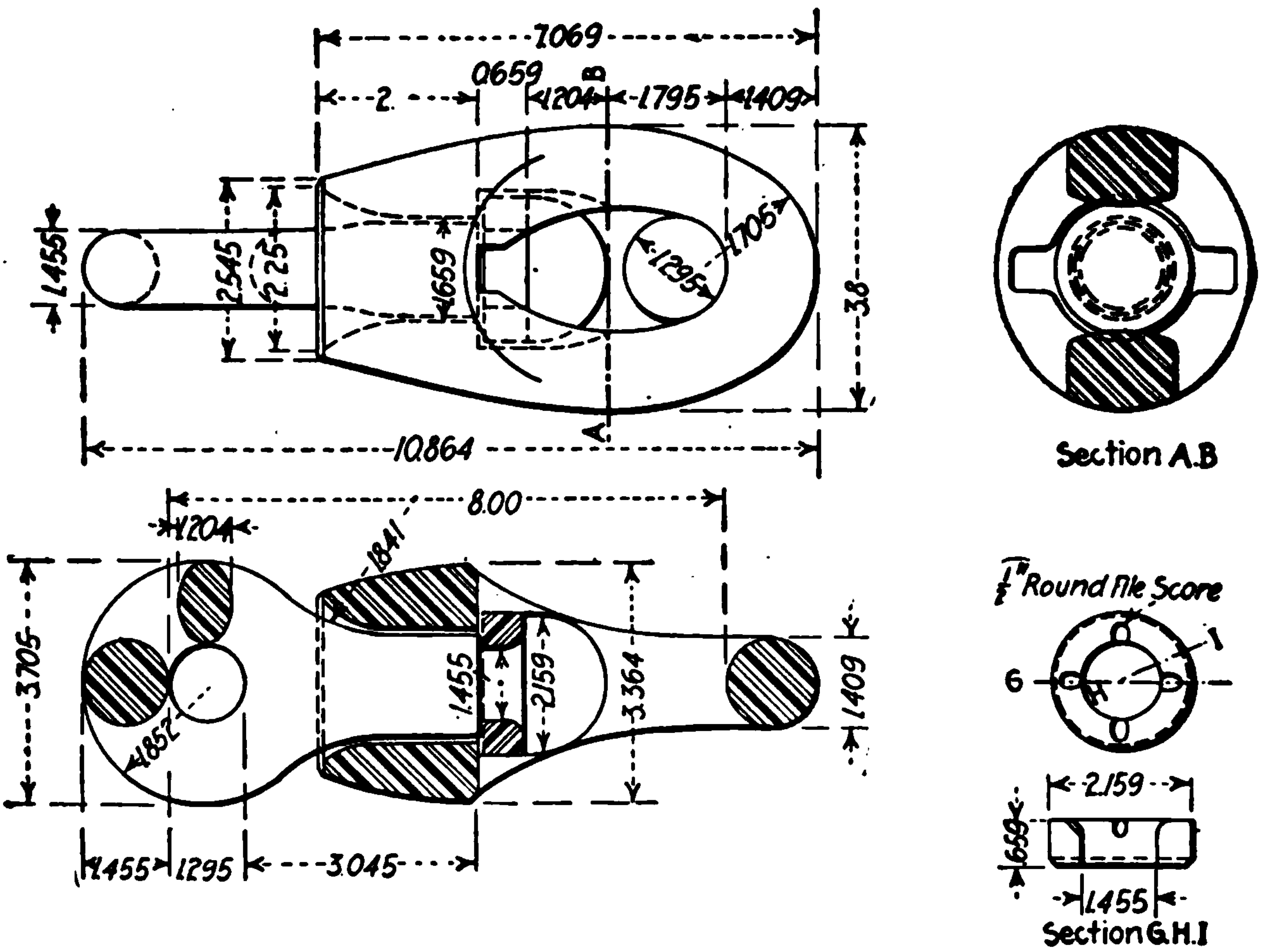


FIG. 359.

KENTER SHACKLE

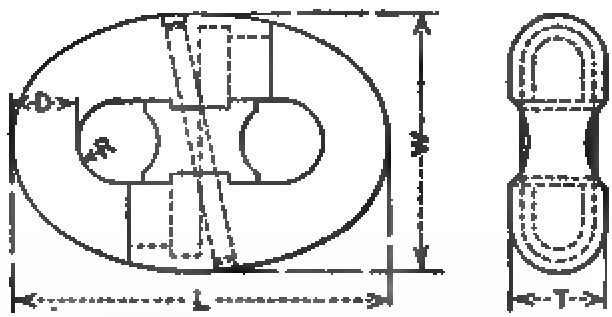


Fig. 360.

Dimensions of Kenter Shackles.

M/M	D	20	22	24	26	28	30	33	36
Approx. ins.	D	13/16	7/8	15/16	1	1 1/8	1 3/16	1 5/16	1 3/8
Inches	R	27/32	29/32	31/32	1 1/16	1 1/8	1 3/16	1 1/4	1 5/16
Inches	L	4 3/8	5 1/16	5 3/4	6 1/4	6 3/4	7 1/8	7 7/8	8 1/2
Inches	W	3 3/8	3 5/8	3 7/8	4 1/4	4 5/8	5	5 1/2	6
Inches	T	1 1/4	1 5/16	1 7/16	1 9/16	1 11/16	1 13/16	2	2 3/16
Weight in lbs.	..	2 2	3.3	4 4	6.6	7.75	8.8	11	13.3

M/M	D	39	42	45	48	51	54	57	60	63
Approx. ins.	D	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/8	2 1/4	2 3/8	2 1/2
Inches	R	1 17/32	1 5/8	1 11/16	1 3/4	1 7/8	1 7/16	1 1/2	1 9/16	1 21/32
Inches	L	9 1/4	10	10 5/8	11 3/8	12	12 5/8	13 3/8	14 1/4	14 7/8
Inches	W	6 1/2	7	7 1/2	7 7/8	8 3/8	8 7/8	9 3/8	9 3/4	10 1/4
Inches	T	2 3/8	2 1/2	2 11/16	2 13/16	3 1/8	3 1/4	3 3/8	3 9/16	3 3/4
Weight in lbs.	..	18 8	24.2	30	35	42	52	60	7.25	81.5

M/M	D	66	69	72	75	78	81	84	87	90
Approx. ins.	D	2 5/8	2 3/4	2 13/16	2 15/16	3	3 3/16	3 5/16	3 7/16	3 9/16
Inches	R	1 3/4	1 13/16	1 7/8	1 31/32	2 1/16	2 1/8	2 3/16	2 1/4	2 3/8
Inches	L	15 5/8	16 3/8	17	17 3/4	18 1/2	19 1/8	19 7/8	20 5/8	21 3/8
Inches	W	10 5/8	11 1/8	11 5/8	12 3/8	12 7/8	13 3/8	13 7/8	14 3/8	15
Inches	T	3 15/16	4 1/8	4 5/16	4 1/2	4 5/8	4 13/16	5	5 3/16	5 7/16
Weight in lbs	..	92 5	99	121	135	150	...	...	...	..

MUSHROOM MOORING ANCHORS.

Weight in Lbs.	A.	B.	C.	D.	E.	F.	G.	H.	J.	K.
	′ ″	′ ″	″	′ ″	′ ″	″	″	″	″	″
5,000	5 6	6 9	5½	5 9½	3 10½	13¾	5¾	4¾	4	12
3,600	5 0	5 6	5	5 0	3 6	11⅓	5⅓	4	3⅓	12
1,850	4 0	4 4	4	3 10	2 8¾	9½	4½	3¾	2¾	9
1,200	3 3	3 8	3½	3 1	2 2	8	3½	3	2¼	8½

Weight in Lbs.	L.	M.	N.	O.	P.	Q.	R.	S.	T.	U.
	″	″	″	″	″	″	″	″	″	″
5,000	9½	7	[illegible]	19½	1⅝	3	6	12	9	2⅝
3,600	9	6	3½	17½	1½	2½	5	11	8	2⅛
1,850	6½	5	3¼	14	1¼	2¼	4½	9	7½	2
1,200	6	4½	3	11½	1⅛	2	4	8	7	1⅝

Weight in Lbs.	V.	W.	X.	Y.	Z.	AA.	BB.	CC.	Cotter.
		″	″	″	′	2″	3″	4″	″ ″
5,000	6¾	2⅞	7¾	5	8¾	2¾	4¼	8¼	2 × ⅝
3,600	6	2⅜	7½	4	7	2¼	3½	7½	1¾ × ½
1,850	4¾	2	6¼	3½	5¾	1¾	2¾	6½	1½ × ⅜
1,200	3¾	1⅝	4½	3		1⅝	2¼	5½	1¼ × ⅜

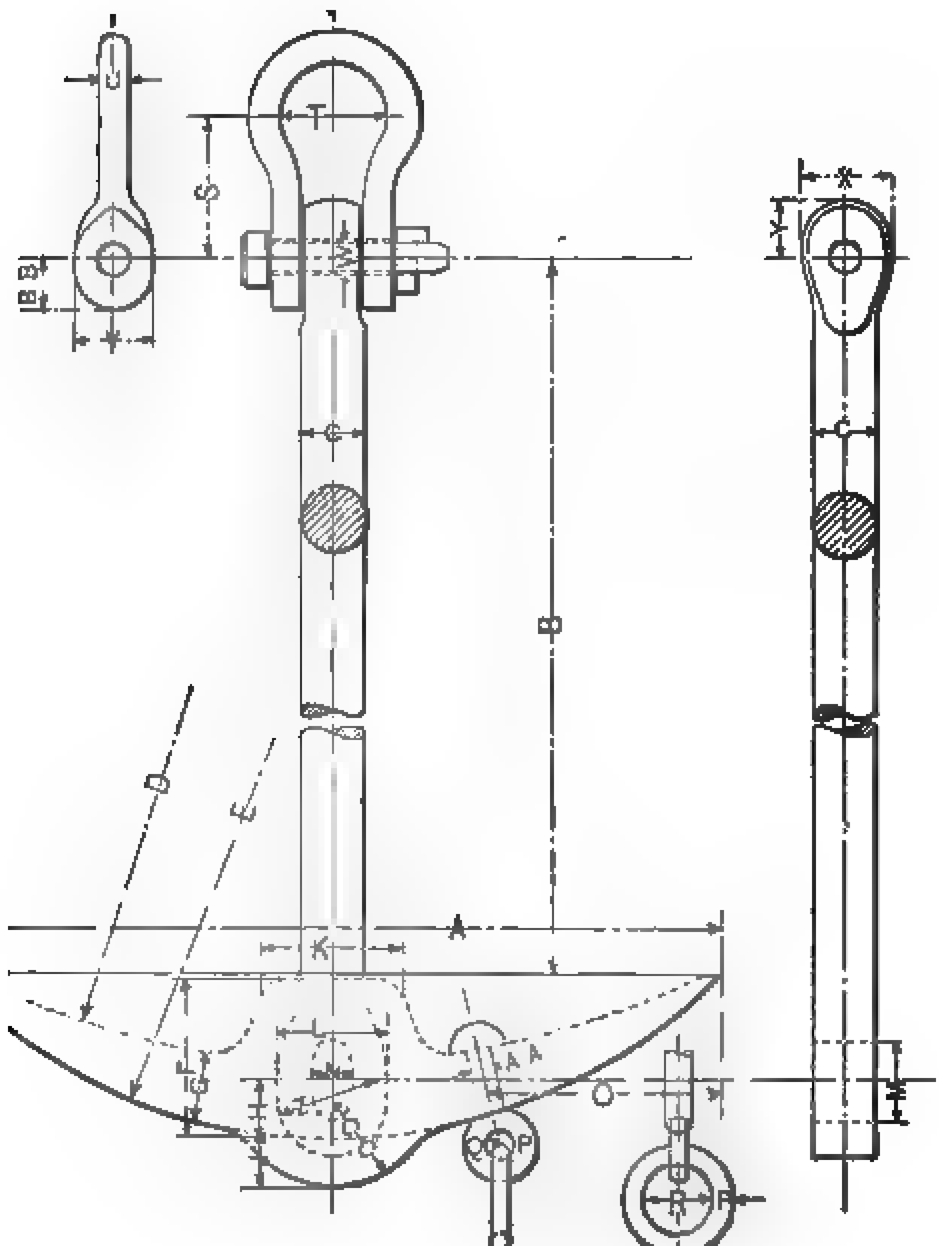


FIG. 361.

CHAPTER II.

BOATS.

The American and the British requirements for boats carried by foreign-going steamships are practically identical, but for vessels employed in the home trade there is much dissimilarity. The following notes, therefore, where they refer to the number of boats to be carried, apply only to ocean-going steamships.

Many of the boats carried on steamships are good examples of what a boat should *not* be. The contractor should not only supply the boat-builder with the dimensions of the boats required, but also with an outline of the mid section, more particularly in the case of life-boats and dinghies. In many cases these boats have much too quick a rise of floor line, making them dangerous to step into in the light condition. In addition, their scantlings are often inadequate for working boats exposed at all times to the extremes of weather. With a view to supplying a good guide as to what are wholesome proportions for the various classes of boats hung under davits, the subjoined diagram has been prepared by the writer. It is based on a long experience in designing and building these craft.

When outline plans of boats are prepared, the following points should be noted: —

Minimum clear distance between thwarts, 2′ 2″. Centre of row crutches = 10″ abaft aft edge of thwarts. Top of thwarts or benches = 9″ below bottom of row crutch. In single-banked boats stroke is always starboard. Breadth of transom = $\frac{2}{3}$ rds. midship top breadth (except in gigs). Rabbet of transom = half the stern depth above base. Siding of hog = twice the siding of keel. Moulding of hog = .4 of the siding. Scarphs of keel, etc. = $4\frac{1}{2}$ times the siding.

Spars. — Diameter of Mast, $\frac{1}{4}''$ . . per foot of length.
" " Gaff, $\frac{3}{16}''$ . . . " " " "
" " Topsail Yard, $\frac{1}{5}''$. " " " "
" " Boom, $\frac{3}{16}''$ . . . " " " "
" " Spread Yard, $\frac{1}{7}''$. " " " "
" " Bowsprit, $\frac{3}{8}''$ . . " " " "

Sheer. — Gigs sheer forward .5″ per foot ; aft .25″ per foot.
Cutters " " .43″ " " ; " .2″ " "
Dinghies " " .53″ " " ; " .22″ " "

Sheers taken with L.W.L. parallel with keel.

PROPORTION OF ROW BOATS.

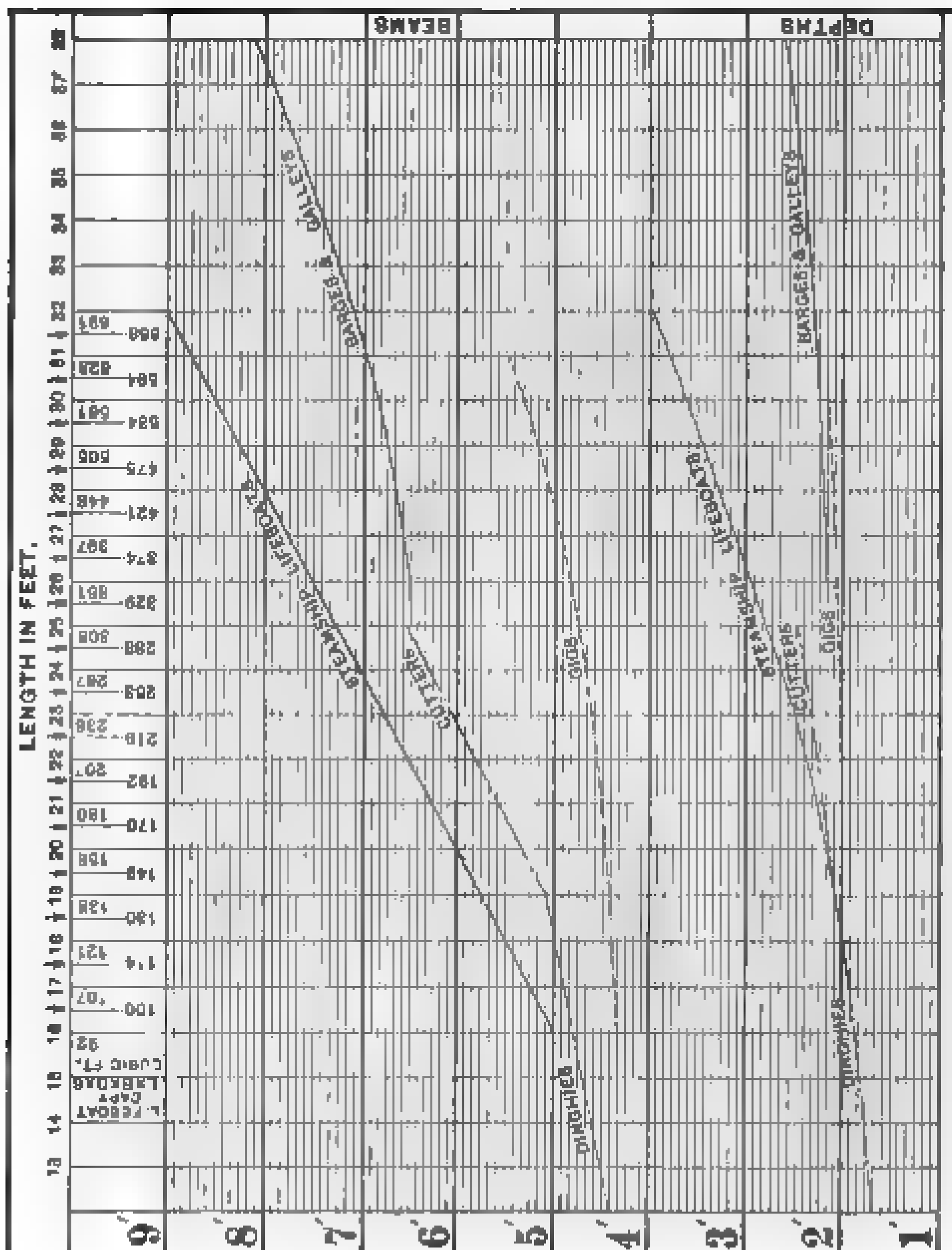


FIG. 362.

Sails.—The sail area may with advantage be based on the midship section area measured to underside of thwarts multiplied by 12. $A \times 12 =$ sail area.

Scantlings.—The scantlings may be as given in the table which shows the requirements for boats of the Royal Navy, or these may be modified by the designer in accordance with his own experience.

Slings.—Inspectors should insist that all sling plates and lifting rings be tested. The following table shows the tests to which these fittings are usually subjected for the various classes of boats.

TABLE SHOWING DIAMETER OF RING BOLTS

With Proof Test to be Applied and the Descriptions of Boats to which the Various Sizes are to be fitted.

Type of Boat.	Length of Boat.	Diameter of Bolt.	Proof Test.
	Feet.	Inches.	Tons.
Dinghies	12	$\frac{1}{2}$	1
Dinghies	14	$\frac{9}{16}$	$1\frac{1}{4}$
Cutter gigs, Galleys, Gigs, Whalers	32 to 18	$\frac{5}{8}$	$1\frac{9}{16}$
Cutters	20, 18, and 16	$\frac{11}{16}$	2
Cutters	23	$\frac{3}{4}$	$2\frac{1}{4}$
Cutters	25 and 26	$\frac{13}{16}$	$2\frac{7}{8}$
Cutters	27 and 28	$\frac{7}{8}$	$3\frac{1}{16}$
Cutters	30 and 32	1	4
Cutters	34	$1\frac{5}{8}$	$5\frac{1}{16}$

TABLE SHOWING POSITION OF MASTS, TACK BLOCKS, AND TACK HOOKS.

	Cutter Gigs		Gigs.								Whalers.		
	23′ 0″	20′ 0″	32′ 0″	30′ 0″	28′ 0″	26′ 0″	24′ 0″	22′ 0″	20′ 0″	18′ 0″	27′ 0″	25′ 0″	23′ 0″
Centre of foremast from fore part of stem.	3 8	2 11	4 11	4 6	4 6	4 5	4 3	3 3	2 11	2 9	4 6	4 4	4 3
Centre of midship position of mast from fore part of stem	11 6	9 10	15 9	14 9	13 9	12 10	11 10	10 10	9 10	8 10	13 6	12 6	11 6
Centre of mainmast from fore part of stem	13 3	11 2	18 2	16 8	16 5	15 0	14 1	12 6	11 2	10 8	15 6	14 3	13 3
Tack block for mast when in midship position from fore part of stem	7 8	6 9	10 6	9 8	8 8	8 7	7 7	7 4	6 9	6 0	8 6	8 2	7 8
Tack block for mainmast from fore part of stem.	9 5	8 1	13 0	11 6	11 4	10 9	9 10	9 0	8 1	7 6	10 7	10 1	9 5
Tack hook for foremast at side from fore part of stem	2 4	1 8	2 10	2 8	2 8	2 7	2 6	1 11	1 8	1 6	2 7	2 5	2 4
Tack hook at side for mast when in midship position from fore part of stem	9 9	8 1	12 10	12 6	12 0	11 1	10 1	9 1	8 1	7 1	11 3	10 9	9 9
Tack hook at side for mainmast from fore part of stem.	11 6	9 5	15 8	14 2	14 0	13 3	12 4	10 9	9 5	8 11	13 10	12 6	11 6

	Cutters.											Dinghies.	
	34′ 0″	32′ 0″	30′ 0″	28′ 0″	27′ 0″	20′ 0″	25′ 0″	23′ 0″	20′ 0″	18′ 0″	16′ 0″	14′ 0″	12′ 0″
Centre of foremast from fore part of stem.	11 3	10 3	9 0	7 9	7 3	7 0	6 10	6 6	4 10	6 0	5 6	4 9	3 10
Centre of mainmast from fore part of stem.	22 6	21 2	19 10	18 7	...	...	...	.	...	...	..	...	...

DIMENSIONS AND

	Cutters.	Cutters.	Cutters	Cutters.	Cutters.	Cutters.	Cutters	Cutters.	Cutter Gigs	Cutters.
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
Length Extreme	34 0	32 0	30 0	28 0	27 0	26 0	25 0	23 0	23 0	20 0
Breadth	8 10	8 6	8 1	7 6	7 6	7 3	7 3	6 11	5 6	6 4
Depth	2 11½	2 10	2 8¾	2 6½	2 6¼	2 5½	2 5¼	2 4½	2 2	2 2
Keel, Sided	3¼″	3″	3″	3″	3″	2¾″	2¾″	2¾″	2⅝″	2⅝″
Keel, Moulded	5″	4¾″	4½″	4½″	4⅜″	4⅛″	4½″	4½″	4″	4¼″
Stem and stern post, sided	3″	2¾″	2¾″	2¾″	2⅝″	2½″	2¼″	2½″	2⅜″	2¼″
Transom, thick	1½″	1⅝″	1½″	1½″	1½″	1⅜″	1⅜″	1⅜″	1¼″	1⅜″
Floors, Sided	1¾″	1½″	1½″	1½″	1½″	1⅜″	1⅜″	1⅜″	1¼″	1¼″
Floors, Moulded	1½″	1⅝″	1⅝″	1⅝″	1⅝″	1½″	1¼″	1¼″	1″	1″
Floors, Grown to shape	No. 4	No. 4	No. 4	No. 4	No. 4	No. 4	No. 4	No. 2	No. 2	No. 2
Futtocks, Sided	1½″	1⅝″	1⅝″	1⅝″	1⅝″	1⅜″	1½″	1¼″	1″	1″
Futtocks, Moulded, Lower end	1⅛″	1″	1″	1″	1″	⅞″	⅞″	⅞″	⅞″	⅞″
Futtocks, Moulded, Upper end	...	...	...	...	...	...	...	...	...	...
Gunwales, Deep	2¼″	2″	2″	2″	2″	1⅞″	1⅞″	1⅞″	1½″	1¾″
Gunwales, Thick	2¼″	2⅜″	2½″	2½″	2¼″	2″	2″	2″	1½″	1½″
Breasthooks	No. 2	No. 2	No. 2	No. 2	No. 2	No. 2	No 2	No. 2	No. 1	No 2
Thwarts, Fixed	6	6	5	5	5	4	4	4	6	4
Thwarts, Portable	1	1	1	1	1	1	1	1	...	1
Thwarts, Gun platform	1	1	1	1	1	1	1	...	...	...
Mast thwarts, Thick	1¾″	1¾″	1½″	1⅜″	1½″	1⅛″	1½″	1½″	...	1⅜″
Mast thwarts, Broad	9½″	9½″	9½″	9½″	9″	9″	9″	9″	...	8½″
Other thwarts, Thick	1½″	1½″	1½″	1½″	1¼″	1¼″	1¼″	1¼″	1¼″	1½″
Other thwarts, Broad	7″	7″	7″	7″	7″	7″	7″	7″	7″	7″
Knees to thwarts, sided	1¼″	1¼″	1¼″	1¼″	1¼″	1¼″	1¼″	1¼″	⅞″	1⅛″
Thickness of plank when finished	½″	½″	½″	½″	½″	7/16″	7/16″	7/16″	7/16″	7/16″
Strakes, No., about	No 16	No. 16	No. 15	No. 15	No. 15	No. 15	No. 15	No. 14	No 14	No. 14
No. of oars, provision to be made for	14	14	12	10	10	10	10	8	4	8

SCANTLINGS OF ROW BOATS.

Cutter Gigs.	Cutters.	Cutters.	Dinghy.	Dinghy.	Galley or Gig.	Galley or Gig.	Gig.	Whaler.	Gig.	Whaler.	Gig.	Whaler.	Gig.	Gig.	Gig.
′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
20 0	18 0	16 0	14 0	12 0	32 0	30 0	28 0	27 0	26 0	25 0	24 0	23 0	22 0	20 0	18 0
5 6	6 0	6 7	5 2	5 0	5 6	5 6	5 6	5 6	5 6	5 6	5 6	5 6	5 6	5 6	5 0
2 2	2 2	2 1	2 2	2 1	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2
2¼″	2¼″	2¼′	2⅛″	2⅛″	2⅛″	2⅛″	2⅛″	2⅛″	2⅛″	2⅛″	2⅛″	2⅛″	2⅛″	2⅛″	2⅛″
4″	4″	4″	3½″	3½″	3⅜″	3⅜″	3⅜″	3⅜″	3⅜″	3⅜″	3⅜″	3⅜″	3⅜″	3⅜″	3⅜″
2⅛″	2⅛″	2⅛″	2⅛″	2⅛″	1⅞″	1⅞″	1⅞″	1⅞″	1⅞″	1⅞″	1⅞″	1⅞″	1⅞″	1⅞″	1⅞″
1⅛″	1⅛″	1⅛″	1⅛″	1⅛″	1″	1″	1″		1″		1″		⅞″	⅞″	⅞″
1⅛″	1″	1″	1″	1″	1″	1″	1″	1″	1″	1″	1″	1″	1″	1″	1″
1″	⅞″	⅞″	⅞″	⅞″	⅞″	⅞″	⅞″	⅞″	⅞″	⅞″	⅞″	⅞″	⅞″	⅞″	⅞″
No. 2	No. 2	No 2	No. 2	No. 2	No. 4	No. 4	No. 4	No. 4	No. 4	No 4	No. 4	No. 4	No. 4	No. 4	No. 4
1″	⅞″	⅞″	⅞″	⅞″	1″	1″	1″	1″	1″	1″	1″	1″	1″	1″	1″
¾″	⅝″	⅝″	⅝″	⅝″	¾″	¾″	¾″	¾″	¾″	¾″	¾″	¾″	¾″	¾″	¾″
...	...	...	...	...	½″	½″	½″	½″	½″	½″	½″	½″	½″	½″	½″
1½″	1⅜″	1⅜″	1⅜″	1⅜″	1½″	1½″	1½″	1½″	1½″	1½″	1½″	1½″	1½″	1½″	1½″
1⅜″	1⅜″	1⅜″	1⅜″	1⅜′	1⅜″	1⅜″	1⅜″	1⅜″	1⅜″	1⅜″	1⅜″	1⅜″	1⅜″	1⅜″	1⅜″
No. 1	No. 2	No. 3	No. 1	No. 1	No. 1	No. 1	No. 1	No. 2	No. 1	No. 2	No. 1	No. 2	No. 1	No. 1	No. 1
4	3	3	2	2	7	7	7	6	6	5	5	5	5	4	4
...	1	1	1	1	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	1⅛″	1⅛″	...	...	...	...	...	...	...	...	...	...	...	...	...
...	8″	8″	...	...	...	...	...	...	...	...	...	...	...	...	...
1⅛″	1⅛″	1⅛″	1⅛″	1⅛″	1″	1″	1″	1″	1″	1″	1″	1″	1″	1″	1″
7″	7″	7″	7″	7″	7″	7″	7″	7″	7″	7″	7″	7″	7″	7″	7″
⅞″	1⅛″	1″	⅞″	⅞″	⅞″	⅞″	⅞″	⅞″	⅞″	⅞″	⅞″	⅞″	⅞″	⅞″	⅞″
7/16″	7/16′	7/16″	⅝″	⅝″	⅝″	⅝″	⅝″	⅝″	⅝″	⅝″	⅝″	⅝″	⅝″	⅝″	⅝″
No 14	No. 13	No. 13	No. 13	No. 13	No. 13	No. 13	No. 13	No. 13	No. 13	No. 13	No. 13	No. 13	No. 13	No 13	No. 13
4	6	6	6	6	6	6	6	5	5	5	4	4	4	4	4

YACHTS' LAUNCHES.

Length.	Beam.	Depth.	Draft Aft.	Weight Complete.	Speed in Knots.	Class of Machinery.*
′ ″	′ ″	′ ″	′ ″	Cwts.		H.P.
16 0	4 3	1 10	1 4	8½	5	5
18 0	4 6	2 0	1 6	10	6	5
20 0	5 0	2 2	1 6	12	6	5
22 0	5 3	2 6	1 8	16	7	10
23 6	5 4	2 8	2 0	18	7½	15
25 0	5 6	2 10	2 0	19	8	15
27 0	6 0	2 10	2 4	25	10	25
30 0	6 3	3 0	2 4	30	10	25
35 0	6 6	3 2	2 10	45	12	35
45 0	7 6	4 0	3 0	90	12	50
55 0	8 6	5 3	3 10	140	12	80

* Compound engines with watertube boilers.

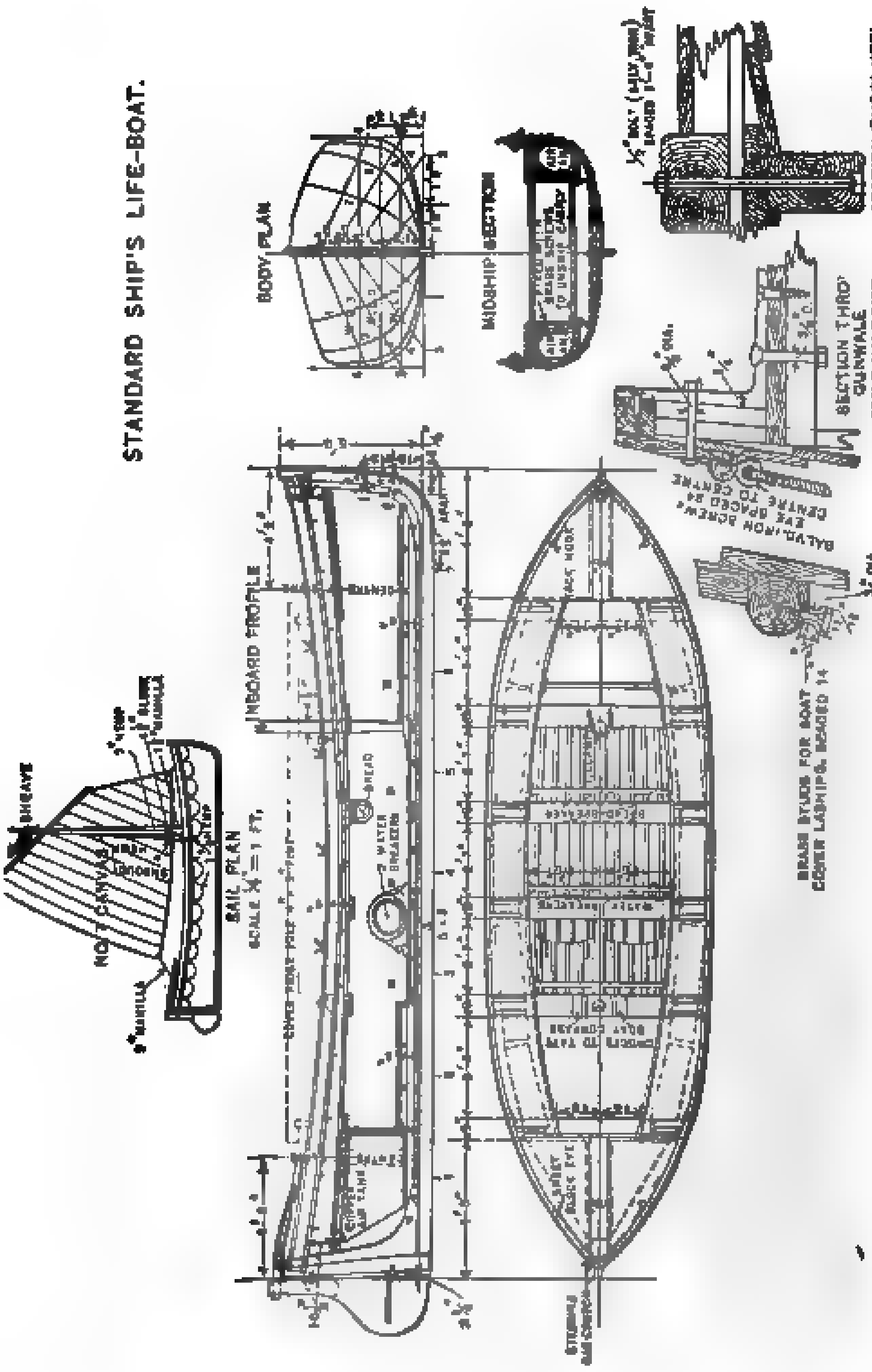

STANDARD SHIP'S LIFE-BOAT.
BODY PLAN
MIDSHIP SECTION
SECTION THRO' KEEL
SECTION THRO' GUNWALE
SCALE HALF SIZE
INBOARD PROFILE
SAIL PLAN
SCALE 1/4" = 1 FT.
NO. 1 CANVAS
WATER BREAKER

FIG. 363.

CHAPTER III.

BRITISH RULES FOR STEAMSHIPS CARRYING PASSENGERS, BOATS AND LIFE-SAVING APPLIANCES.

(*a*) Ships of Division A, Class 1, shall carry boats placed under davits, fit and ready for use, and having proper appliances for getting them into the water, in number and capacity as prescribed by the table in the appendix to these Rules (see page 433); such boats shall be equipped in the manner required by, and shall be of the description defined in, the General Rules appended hereto.

(*b*) Masters or owners of ships of this class claiming to carry fewer boats under davits than are given in the table must declare before the collector or other officers of customs, at the time of clearance, that the boats actually placed under davits are sufficient to accommodate all persons on board, allowing 10 (ten) cubic feet of boat capacity for each adult person, or "statute adult."

(*c*) Not less than half the number of boats placed under davits, having at least half the cubic capacity required by the tables, shall be boats of Section A or Section B. The remaining boats may also be of such description, or may, in the option of the shipowner, conform to Section C, or Section D, provided that not more than two boats shall be of Section D.

(*d*) If the boats placed under davits in accordance with the table do not furnish sufficient accommodation for all persons on board, then additional wood, metal, collapsible or other boats of approved description (whether placed under davits or otherwise), or approved life-rafts, shall be carried. One of these boats may be a steam launch; but in that case the space occupied by the engines and boilers is not to be included in the estimated cubic capacity of the boat.

Subject to the provisions contained in paragraph (*f*) of these rules, such additional boats or rafts shall be of at least such carrying capacity that they and the boats required to be placed under davits by the table provide together in the aggregate, in vessels of 5,000 tons gross and upwards, three fourths, and in vessels of less than 5,000 tons gross, one half, more than the minimum cubic contents required by column 3 of the table. For this purpose 3 cubic feet of air-case in the life-raft is to be estimated as 10 cubic feet of internal capacity. Provided always that *the rafts* will accommodate all the persons for which they are to

be certified under the Rules, and also have 3 cubic feet of air-case for each person.

All such additional boats or rafts shall be placed as conveniently for being available as the ship's arrangements admit of, having regard to the avoidance of undue encumbrance of the ship's deck, and to the safety of the ship for her voyage.

(*e*) In addition to the life-saving appliances before mentioned, ships of this class shall carry not less than one approved life-buoy for every boat placed under davits. They shall also carry approved life-belts, or other similar approved articles of equal buoyancy suitable for being worn on the person, so that there may be at least one for each person on board the ship.

(*f*) Provided, nevertheless, that no ship of this class shall be required to carry more boats or rafts than will furnish sufficient accommodation for all persons on board.

General Rules.

Boats.—All boats shall be constructed and properly equipped as provided by these Rules, and all boats and other life-saving appliances are to be kept ready for use to the satisfaction of the Board of Trade. Internal buoyancy apparatus may be constructed of wood, or of copper or yellow metal, of not less than 18 ounces to the superficial foot or of other durable material.

Section A. A boat of this section shall be a life-boat, of whale-boat form, properly constructed of wood or metal, having for every 10 cubic feet of her capacity, computed as in Rule 2, at least one cubic foot of strong and serviceable enclosed air-tight compartments, so constructed that water cannot find its way into them. In the case of metal boats, an addition will have to be made to the cubic capacity of the air-tight compartments, so as to give them buoyancy equal to that of the wooden boat.

Section B. A boat of this section shall be a life-boat, of whale-boat form, properly constructed of wood or metal, having inside and outside buoyancy apparatus together equal in efficiency to the buoyancy apparatus provided for a boat of Section A. At least one-half of the buoyancy apparatus must be attached to the outside of the boat.

Section C. A boat of this section shall be a life-boat, properly constructed of wood or metal, having some buoyancy apparatus attached to the inside and (or) outside of the boat equal in efficiency to one-half of the buoyancy apparatus provided for a boat of Section A or Section B. At least one-half of the buoyancy apparatus must be attached to the outside of the boat.

Section D. A boat of this section shall be a properly constructed boat of wood or metal.

Section E. A bōat of this section shall be a boat of approved construction, form and material, and may be collapsible.

Cubic Capacity. — The cubic capacity of a boat shall be deemed to be her cubic capacity, ascertained (as in measuring ships for tonnage capacity) by Simpson's rule; but as the application of that rule entails much labor, the following simple plan, which is approximately accurate, may be adopted for general purposes, and when no question requiring absolute correct adjustment is raised: —

Measure the length and breadth outside and the depth inside. Multiply them together and by .6; the product is the capacity of the boat in cubic feet. Thus, a boat 28 feet long, 8 feet 6 inches broad, and 3 feet 6 inches deep, will be regarded as having a capacity of $28 \times 8.5 \times 3.5 = 499.8$, or 500 cubic feet. If the oars are pulled in rowlocks, the bottom of the gunwale of the rowlock is to be considered the gunwale of the boat for ascertaining her depth.

Number of Persons for Boats. — The number of persons a boat of Section A shall be deemed fit to carry shall be the number of cubic feet, ascertained as above, divided by 10.

The number of persons a boat of Section B, Section C, Section D, or Section E shall be deemed fit to carry, shall be the number of cubic feet, ascertained as per rule, divided by 8. The space in the boat shall be sufficient for the seating of the persons carried in it, and for proper use of the oars.

Appliances for Lowering Boats. — Appliances for getting a boat into the water must fulfil the following conditions: — Means are to be provided for speedily, but not necessarily simultaneously or automatically, detaching the boats from the lower blocks of the davit tackles; the boats placed under davits are to be attached to the davit tackles and kept ready for service; the **davits** are to be strong enough and so spaced that the boats can be swung out with facility; the points of attachment of the boats to the davits are to be sufficiently away from the ends of the boats to insure their being easily swung clear of the davits; the boat's **chocks** are to be such as can be expeditiously removed; the davits, falls, blocks, eyebolts, rings, and the whole of the tackling are to be of sufficient strength; the boat's **falls** are to be long enough to lower the boat into the water with safety when the vessel is light. The **life-lines** shall be fitted to the davits, and be long enough to reach the water when the vessel is light; and hooks are not to be attached to the lower tackle blocks.

Equipments for Collapsible or other Boats, and for Life-Rafts. — In order to be properly equipped, each boat shall *be provided* as follows: —

(*a*) With the full single-banked complement of oars, and two spare oars.

(*b*) With two plugs for each plug-hole, attached with lanyards or chains, and one set and a half of thole pins or crutches, attached to the boat by sound lanyards.

(*c*) With a sea-anchor, a baler, a rudder and a tiller, or yoke lines, a painter of sufficient length, and a boat-hook. The rudder and the baler to be attached to the boat by sufficiently long lanyards, and kept ready for use. In boats where there may be a difficulty in fitting a rudder, a steering oar may be provided instead.

(*d*) A vessel to be kept filled with fresh water shall be provided for each boat.

(*e*) Life-rafts shall be fully provided with a suitable approved equipment.

Additional Equipments for Boats of Section A and Section B. — In order to be properly equipped, each boat of Sections A and B, in addition to being provided with all the requisites laid down in Rule, shall be equipped as follows, but not more than four boats in any one ship require to have this outfit, and where boats of Sections A or B are carried in lieu of boats of Sections C or D, this additional outfit need not be insisted on: —

(*a*) With two hatchets or tomahawks, one to be kept in each end of the boat, and to be attached to the boat by a lanyard.

(*b*) With mast or masts, and with at least one good sail, and proper gear for each.

(*c*) With a line becketted round the outside of the boat and securely made fast.

(*d*) With an efficient compass.

(*e*) With one gallon of vegetable or animal oil, and a vessel of an approved pattern, for distributing it in the water in rough weather.

(*f*) With a lantern trimmed, with oil in its receiver sufficient to burn eight hours.

Number of Persons for Life-Rafts. — The number of persons that any approved life-raft for use at sea shall be deemed to be capable of carrying, shall be determined with reference to each separate pattern approved by the Board of Trade; provided always, that for every person so carried there shall be at least three cubic feet of strong and serviceable enclosed air-tight compartments, constructed so that water cannot find its way into them. Any approved life-raft of other construction may be used, provided that it has equivalent buoyancy to that hereinbefore

described. Every such approved life-raft shall be marked in such a way as to plainly indicate the number of adult persons it can carry.

Buoyant Apparatus. — Approved buoyant apparatus shall be deemed sufficient, so far as buoyancy is concerned, for a number of persons, to be ascertained by dividing the number of pounds of iron which it is capable of supporting in fresh water by 32. Such buoyant apparatus shall not require to be inflated before use, shall be of approved construction, and marked in such a way as plainly to indicate the number of persons for whom it is sufficient.

Life-Belts. — An approved life-belt shall mean a belt which does not require to be inflated before use, and which is capable at least of floating in the water for 24 hours with 15 pounds of iron suspended from it. Life-belts are to be cut out 2 inches under the arm-pits, and fitted so as to remain securely in their place when put on.

Life-Buoys. — An approved life-buoy shall mean either: (*a*) A life-buoy built of solid cork, capable of floating in water for at least 24 hours with 32 pounds of iron suspended from it; or (*b*) A strong life-buoy of any other approved pattern or material, provided that it is capable of floating in water for at least 24 hours with 32 pounds of iron suspended from it, and provided also that it is not stuffed with rushes, cork shavings, or other shavings, or loose granulated cork or other loose material, and does not require inflation before use.

All life-buoys shall be fitted with beckets securely seized, and not less than two of them shall be fitted with life-lines 15 fathoms in length.

Position of Life-Buoys and Life-Belts. Water-tight Compartments. — All life-buoys and life-belts shall be so placed as to be readily accessible to all persons on board, and so that their position may be known to those for whom they are intended.

When ships of any class are divided into efficient water-tight compartments to the satisfaction of the Board of Trade, they shall only be required to carry additional boats, rafts and buoyant apparatus of one-half the capacity required by these Rules, but the exemption shall not extend to life-jackets or similar approved articles of equal buoyancy suitable to be worn on the person.

The table referred to in the foregoing Rules, showing the minimum number of boats to be placed under davits and their minimum cubic contents, follows: —

BOAT CAPACITY FOR STEAMERS.

(British Law.)

Gross Tonnage.	Minimum Number of Boats to be Placed under Davits.	Total Minimum Cubic Contents of Boats to be Placed under Davits $L \times B \times D \times .6$
1	2	3
10,000 and upwards	16	5,500
9,000 and upwards	14	5,250
8,500 and under 9,000	14	5,100
8,000 " " 8,500	14	5,000
7,750 " " 8,000	12	4,700
7,500 " " 7,750	12	4,600
7,250 " " 7,500	12	4,500
7,000 " " 7,250	12	4,400
6,750 " " 7,000	12	4,300
6,500 " " 6,750	12	4,200
6,250 " " 6,500	12	4,100
6,000 " " 6,250	12	4,000
5,750 " " 6,000	10	3,700
5,500 " " 5,750	10	3,600
5,250 " " 5,500	10	3,500
5,000 " " 5,250	10	3,400
4,750 " " 5,000	10	3,300
4,500 " " 4,750	8	2,900
4,250 " " 4,500	8	2,900
4,000 " " 4,250	8	2,800
3,750 " " 4,000	8	2,700
3,500 " " 3,750	8	2,600
3,250 " " 3,500	8	2,500
3,000 " " 3,250	8	2,400
2,750 " " 3,000	6	2,100
2,500 " " 2,750	6	2,050
2,250 " " 2,500	6	2,000
2,000 " " 2,250	6	1,900
1,750 " " 2,000	6	1,800
1,500 " " 1,750	6	1,700
1,250 " " 1,500	6	1,500
1,000 " " 1,250	4	1,200
900 " " 1,000	4	1,000
800 " " 900	4	900
700 " " 800	4	800
600 " " 700	3	700
500 " " 600	3	600
400 " " 500	2	400
300 " " 400	2	350
200 " " 300	2	300
100 " " 200	2	250

Note. — Where in ships already fitted the required cubic contents of boats placed under davits is provided, although by a smaller number of boats than the minimum required by this table, such ships shall be regarded as complying with the rules as to boats to be carried under davits.

In case of vessels under 200 tons gross tonnage, the capacity of any boat to be supplied should not be less than 125 feet. If, however, in any case this rule be found impracticable, a discretion may then be exercised by the Board of Trade.

In cases where a small vessel is unable to carry more than one boat, a discretion may be exercised by the Board of Trade; but whenever one boat only is carried, there must be proper provision to enable it to be placed readily in the water on either side of the ship.

Capacity and Form of Life-Boats. — As regards the boats of Sections *A*, *B*, *C*, and *D*, Rule 1, the surveyors will see that the requirements of the Rules are observed, and that the capacity of the boats, and the number of persons they are fit to carry, are ascertained by Rules 2 and 3 (page 430). In measuring boats the length and breadth are to be regarded as the extreme dimensions measured to the outside of the plank. The number of persons for which a boat is to be passed is, however, subject to the further condition that the space in the boat shall be sufficient for the seating of them all, and the proper use of the oars. That this requirement is fulfilled must be ascertained by practical experiment in all cases before a declaration is granted, unless one or more boats in a ship are of the same pattern, when only one of such boats need be tested. Life-boats (except those of Section *C*) should be built whale-boat fashion, both ends alike. In ships which have been fitted with boats previous to the Rules coming into force, square-sterned boats need not be condemned if fitted with the required amount of buoyancy, but all life-boats of Sections *A* and *B* subsequently supplied, or supplied to new ships, must be built whale-boat fashion. All collapsible boats, and all boats whether collapsible or not, if constructed of any material other than wood or metal, must be in accordance with a pattern approved by the Board of Trade before they are passed as a portion of the life-saving appliances required by the Rules.

Stowage of Boats. — All boats required by the Rules to be placed under davits are to be kept fit and ready for use; and when they are swung inboard and resting on the chocks, the chocks are to be so constructed that the boat can be at once swung outboard without requiring to be lifted by the tackles — *i.e.*, it shall not be necessary to take more than the weight of the boat.

The manner in which the additional boats, not requiring to be

placed under davits, are to be stowed, will vary in different ships, but they must be stowed to the satisfaction of the surveyors, so as to be as readily available for use as is practicable, having due consideration to the circumstances mentioned in the Rules.

In all cases where boats are stowed on skids, a batten and space platform of about 2½″ planks should be fitted from skid to skid, under and alongside the boat, when being launched forward or aft, and as a platform for the men.

Equipments.—The equipments for all boats are provided for in the Rules, and surveyors are to see that the requirements are carefully complied with. The painters for boats are not to be less than 20 fathoms in length.

When the Rules require a life-boat of Section *C* to be carried, and owners choose to provide a boat of Section *A* or *B*, the additional equipments required by General Rule 6 for boats of Section *A* and Section *B* need not be insisted on.

Rudder.—In some of the collapsible boats it is difficult to fit a rudder; in this case a steering oar properly fitted may be passed instead.

Buoyancy.—The buoyancy of life-boats of Section *B* must be partly inside and partly outside the boat, and a boat in which it is wholly inside or wholly outside shall not be passed as a boat of Section *B*.

In the case of life-boats of Section *C*, one-half the buoyancy must be outside the boat; the remainder may be either inside or outside, or partly inside and partly outside.

The inside buoyancy for boats of Sections *A*, *B*, and *C*, must consist of strong and serviceable enclosed air-tight compartments, such that water cannot find its way into them.

The outside buoyancy for boats of Section *B* must consist of solid cork covered with canvas, and painted and attached to the outer skin of the boat to the satisfaction of the surveyors, both as regards its position and also as regards its attachment. No other material is to be used unless expressly sanctioned by the Board of Trade. The outside buoyancy must be equal to at least half the buoyancy required for boats of Section *A*, and the inside and outside buoyancy together must equal in efficiency the buoyancy required for a boat of Section *A*.

To effect this 1.25 cubic feet of cork is to be considered as equivalent to 1 cubic foot of air-case.

The foregoing remarks apply to outside buoyancy for boats of Section *C*, excepting that the total buoyancy is only required to be half that of boats of Section *A* or Section *B*. When the solid cork is not permanently attached to the side of the boat in such a

manner that moisture cannot collect between the two surfaces, it will require to be removed every time a declaration is granted to ascertain (1) whether the cork is becoming sodden; (2) whether moisture is collecting between the cork and the skin of the boat, and in that way rotting the wood. The consideration (2) will not apply to metal boats.

Air-Cases, Material and Construction.— Air-cases are required by the Rules to be constructed of wood, or of copper or yellow metal of not less than 18 ounces to the superficial foot, or of other durable material.

The average weight of 18 ounce copper air-cases is about 5 pounds per cubic foot, and if air-cases of other material exceed this weight, the cubic capacity of the air-cases must be correspondingly increased.

As yellow metal in time becomes extremely brittle, copper is far preferable. Zinc is not durable material, and should not be passed; neither should galvanized iron or steel cases be passed for new boats.

A note should be made in each district of all ships whose boats are already filled with galvanized iron or steel air-cases, with a view to their being frequently inspected. Steel or iron air-cases previously passed of less thickness than 21 ounces are not to be rejected so long as they continue in good condition.

Copper and yellow metal air-cases are to be made with proper hook joints not less than three-eighths of an inch in width, hammered well down and soldered, and no other joint is to be passed unless specially approved by the Board of Trade.

The cases are not to exceed four feet in length; they are to be substantially enclosed with wood, which is to be close-jointed so as to cover any exposed part of the air-case, and the wood forming the top is not to be less than one inch in thickness.

The coverings in the boats over the air-cases should be secured with brass screws, so as to enable the cases to be removed without difficulty for examination, and no air-case which is not enclosed from the outer shell of the boat should be passed.

Spaces filled with or containing any material are not to be deemed air-spaces unless specially approved by the Board of Trade.

Copper or yellow metal air-cases must not be carried in contact with the skin of the metal boats.

Where boats not required by the Rules to be fitted with air-cases are so fitted, as, for instance, in some of the collapsible or semi-collapsible boats, these provisions as to air-cases need not be insisted upon.

Steam Launches, etc., Carried by Steamships.— In the cases of launches or other boats propelled by steam power, which

are carried as part of the additional boat equipment required by the Rules made under the provisions of the Merchant Shipping Act, an inspection of the boat, machinery, and boilers, and of the mounting and fitting thereof, should be made. Steam launches must not be passed as a part of the boat equipment required to be under davits.

In case of any vessel provided with a steam launch or boat in addition to the boat capacity required under the Rules, the surveyors need not interfere unless they have reason to believe that there is some defect in the boat, machinery, or boiler, or in the fittings or arrangement thereof, which might be dangerous to life.

Boats Already Supplied.—In carrying these instructions into effect, surveyors are to be careful not to interfere unnecessarily with boats supplied before November, 1890, but in the case of new boats coming under survey for the first time, as well as in all cases in which the fittings of the boats require renewal, the Rules contained in these instructions are to be strictly adhered to.

Appliances for Lowering Boats.—These appliances must be in accordance with Rule 4, of the General Rules, and must, in the surveyor's opinion, be such as not to endanger human life. They should be tested at each survey for renewal of a passenger certificate.

The question of determining whether the requirements of the Rules respecting appliances for lowering boats are complied with in the case of any particular kind of gear coming under the surveyor's notice, shall be left to the principal officers of the districts.

In order to insure uniformity of practice, each principal officer, who may pass any particular disengaging gear, should request the maker to supply 50 copies of the plans and specifications for distribution among the surveyors in the several districts. These copies should be sent to the Board of Trade by the Principal Officer, together with his report upon the gear. No certificates of approval for disengaging gear will be issued.

The Principal Officer should also report to the Board of Trade when any particular disengaging gear has been inspected and deemed unsatisfactory or unsafe, and should explain fully in such report the details which, in his opinion, render it undesirable. No formal certificate of approval will, however, be granted by the Board of Trade or their officers for any special kind of gear.

Life-Rafts, Buoyant Apparatus.—No part of the gear which is intended to bear the weight of the boat must be made of cast iron, and life-rafts are to be approved by the Board of Trade; they are to be supplied with a suitable equipment to the satisfac-

tion of the surveyors, and this must include a sea-anchor, not less than 20 fathoms of hawser, and oars in proportion to the size of the raft.

The number of persons that any approved life-raft for use at sea is to be deemed capable of carrying is the number that the raft is able to seat safely, provided always that for every person so carried there are at least three cubic feet of strong and serviceable enclosed air-tight compartments.

Approved buoyant apparatus is to be deemed sufficient for a number of persons to be ascertained by dividing the number of pounds of iron which it is capable of supporting in fresh water by 32, provided also that the sides and ends of the apparatus shall afford a space of one horizontal foot for each person for whom it is certified, and that a line for the people to cling to is properly becketted all round it. Such buoyant apparatus shall not require to be inflated before use, and shall be of approved construction.

Marking.—Surveyors will note that rafts and buoyant apparatus shall be marked in such a way as to plainly indicate the number of adult persons for which they are deemed sufficient. Plates will be supplied by the Board of Trade to be screwed on to the woodwork of both rafts and buoyant apparatus, indicating this number; and forms of demand (surveys 116 for rafts and 116a for buoyant apparatus) for plates, to be filled up and returned to the Board of Trade, will be issued for the use of the Principal Officer. No raft or buoyant apparatus is to be regarded as finally approved until the marking-plate has been affixed.

Air-Cases of Rafts, etc.—The instructions in the case of life-boats apply equally to life-rafts and buoyant apparatus, so far as the length, weight and enclosure of the air-cases are concerned, excepting that as life-rafts and buoyant apparatus are only intended to be used in cases of extreme need, and are consequently not exposed to the same wear and tear as the life-boats, a minimum weight of 16 ounces, copper or yellow metal, may be passed.

Life-Belts.—No life-belt is to be passed that is not capable of floating in fresh water for 24 hours with 15 pounds of iron suspended from it. It should be cut out 2 inches under the arm-pits, and fitted so as to remain securely in its place when put on. When any other material than solid cork is used for buoyancy, it must be specially approved by the Board of Trade. All new life-belts should be fitted with adjustable shoulder-straps.

It is desirable that notices should be posted indicating the place of stowage of any belts which are not plainly visible to passengers.

Life-Buoys.—No life-buoy stuffed with rushes or with cork shavings or other shavings, or granulated cork, or any loose material, is to be passed. All cork life-buoys are to be built of solid cork, and fitted with lines becketted and securely seized to the life-buoy, and none are to be passed that will not float for 24 hours in fresh water with 32 pounds of iron suspended from them. If life-buoys are not made of solid cork, the pattern and material must be approved by the Board of Trade. No contrivance is to be passed as a life-buoy that requires inflation before use. Life-buoys are to be secured by a toggle and becket, or any other similar method, so that they can be quickly released; they must not be lashed or seized to the rail or any part of the vessel, but must be kept so as to be ready for use at a moment's notice in case of an emergency.

Not less than two of the life-buoys, one on each side of the ship, are to be fitted with life-lines 15 fathoms in length.

Oil-distributing Apparatus.—Vessels for distributing oil are to be to the satisfaction of the surveyors, and are to be so constructed as to distribute the oil evenly and gradually on the surface of the water.

CHAPTER IV.

UNITED STATES NAVIGATION LAWS RELATING TO BOATS AND LIFE-SAVING APPLIANCES.

THE British requirements as to the build of boats, number of oars, life-lines, and the rule for calculating the capacities of life-boats, are similar to the American regulations, excepting that for river steamers the capacity is divided by 7 to give the number of persons carried.

Boat Ladders. — Where ladders or steps are necessary to enable passengers on board to escape conveniently to the life-boats, such steps shall be provided and placed on each side of the steamer, with manropes of suitable size and of sufficient length to reach the water; and one of the means of escape from one deck to another shall be near the stern of the vessel.

Relieving Tackle. — Extra steering apparatus for all steamers carrying passengers, consisting of relieving tackles or tiller, must be provided.

Metal Life-Boats must be constructed of good iron or other suitable metal not less in thickness than 18 B.W.G.

Davits. — All life-boats must, if possible, be carried on cranes or davits; but if impossible so to carry all the life-boats required, the remainder must be stowed near at hand, so as to be easily and readily launched when required.

River Steamers. — Steamers navigating rivers only (except ferry-boats, canal-boats, and towing-boats, of less than 50 tons) must have one good substantial boat. The cubic capacity of such boat as found by the rule given on p. 444 divided by 7 will determine the number of persons to be carried.

Freight, Canal, and Towing Steamers. — Freight, canal, and towing steamers of less than 50 tons must be equipped with boats or rafts, as, in the opinion of the inspectors, may be necessary, in case of disaster, to secure the safety of all persons on board.

Excursions by Permit. — Steamers making an excursion under a permit must have at least one life-boat, and shall be equipped with other life-boats, or their equivalents, as, in the

judgment of the inspectors, will best secure the safety of all persons on board in case of disaster.

Automatic Plug.—All metal life-boats hereafter built shall be furnished with an automatic plug.

River Passenger Steamers.—Passenger steamers navigating rivers (excepting steamers of 100 gross tons and under, hereinafter provided for) must be supplied, in addition to the boat required in the paragraph "River Steamers," with life-boats in proportion to their tonnage, as follows:

Steamers over 100 and not over 300 gross tons	1 boat.
Steamers over 300 and not over 600 gross tons	2 boats.
Steamers over 600 and not over 900 gross tons	3 boats.
Steamers over 900 and not over 1,200 gross tons	4 boats.
Steamers over 1,200 gross tons	5 boats.

Aggregate Capacity.—The aggregate capacity of life-boats on steamers navigating the Red River of the North and rivers whose waters flow into the Gulf of Mexico and their tributaries, shall not be less than 120 cubic feet to each boat for the number of boats as given in the table; and for life-boats on steamers navigating other rivers than those named, the aggregate capacity shall not be less than 180 cubic feet to each boat as given in the table; and where smaller life-boats are employed for either class of river steamers, their aggregate capacity shall not be less than the aggregate capacity of the larger boats; *provided, however*, that river steamers required, under the table, to carry more than two boats, may, where the owners prefer to do so, supply the boat capacity above that number with a good, substantial life-raft or rafts, such raft or rafts to be of an aggregate carrying capacity not less than that of the boats so omitted.

Capacity may Equal Complement.—No steamer embraced in the foregoing section shall be required to have more life-boats, or of a greater capacity, than sufficient to carry the passengers allowed by the certificate of inspection (including the crew). One of the life-boats, unless exempted by the supervising inspector, must be made of metal.

Life-Boats for Ocean Steamers.—The total capacity of life-boats, or of life-boats and life-rafts, on steamers navigating the ocean (except steamers of 100 gross tons and under, hereinafter provided for), shall not be less than the capacity given, according to tonnage, in the following table:

BOAT CAPACITY FOR OCEAN STEAMERS.

(American Law.)

Gross Tonnage.	Total Capacity of Boats in Cubic Feet.
Steamers over:	
100 and not over 200	540
200 " " 300	720
300 " " 400	1,080
400 " " 500	1,260
500 " " 1,000	1,620
1,000 " " 1,500	1,800
1,500 " " 2,000	2,160
2,000 " " 2,500	2,340
2,500 " " 3,000	2,700
3,000 " " 3,500	2,880
3,500 " " 4,000	3,240
4,000 " " 5,000	3,420
5,000 " " 5,500	3,870
5,500 " " 6,000	4,320
6,000 " " 6,500	4,770
6,500 " " 7,000	5,220
7,000 " " 7,500	5,670
7,500 " " 8,000	6,120
8,000 " " 8,500	6,570
8,500 " " 9,000	7,020
9,000 " " 9,500	7,470
9,500 " " 10,000	7,920
10,000 " " 10,500	8,145
10,500 " " 11,000	8,370
11,000 " " 11,500	8,595
11,500 " " 12,000	8,820
12,000 " " 12,500	9,045
12,500 " " 13,000	9,270
13,000 " " 13,500	9,495
13,500 " " 14,000	9,720
14,000 " " 14,500	9,945
14,500 " " 15,000	10,170
15,000	10,395

Note. — Not more than one third of the boat capacity required on ocean steamers may be substituted by its equivalent in approved **life rafts** or **approved collapsible** (folding) life-boats.

These boats must be of suitable dimensions, and each **not less than 180** ***cubic feet*** **capacity.** (For good proportions of boats, see **diagram on p. 421.**)

LIFE-BOATS FOR STEAMERS NAVIGATING NORTHWESTERN LAKES, BAYS, AND SOUNDS.

Gross Tonnage.	No. of Boats.	Capacity of Boats.
Steamers over:		Cu. Ft.
100 and not over 200.	2	360
200 " " 300.	3	540
300 " " 400.	4	720
400 " " 500.	5	900
500 " " 1,000.	6	1,080
1,000 " " 1,500.	7	1,260
1,500 " " 2,000.	8	1,440
2,000 " " 2,500.	9	1,620
2,500 " " 3,000.	10	1,800
3,000 " " 3,500.	11	1,980
3,500 " " 4,000.	12	2,160
4,000 " " 4,500.	13	2,340
4,500 " " 5,000.	14	2,835
5,000 " " 5,500.	15	3,330

Note on Table.—Steamers above 5,500 gross tons shall be furnished with an additional boat of not less than 495 cubic feet capacity for each additional 500 tons burden, or fraction thereof; or if the owners or agents prefer, two boats may be used; *provided*, the aggregate capacity shall be the same as the one boat described.

These boats shall be substantially built with reference to the trade in which the steamer is engaged, and shall not be of less dimensions than 20 ft. × 5 ft. × 3 ft.,* unless, where smaller life-boats are employed, their aggregate capacity shall equal the aggregate capacity of the larger boats; *provided, however*, that no steamer shall be required to have more life-boats than sufficient to carry the passengers she is allowed by the certificate of inspection, together with her officers and crew.

Not more than one third of the boat capacity required on lake, bay, and sound steamers may be substituted by its equivalent in approved life-rafts or approved collapsible (folding) life-boats.

* For good proportions, see diagram on page 421.

Marking of Boats.—All wood boats required on steam-vessels shall have branded or cut on the stem thereof the net cubic feet contents of such boats, figured as follows:

Multiply the outside length, outside width, and inside depth together and the product by .6, and divide the product by 10 for ocean, lake, bay, or sound steamers; and for river steamers, divide the product by 7; the quotient will be the number of persons such a boat is allowed to carry.

Example.—The carrying capacity of a boat 20 feet in length, 5 feet 6 inches in breadth, and 2 feet 3 inches deep, will be determined as under:

For ocean, lake, bay, or sound steamers,

$$\frac{20 \times 5.5 \times 2.25 \times .6}{10} = \frac{148.5}{10} = 15 \text{ persons.}$$

For river steamers, same boat, $\frac{148.5}{7} = 21$ persons.

Metal boats shall have net cubic feet measurement painted on stem in black letters and figures not less than $\frac{3}{4}$ inch high on a white ground.

Every life-raft shall have stencilled on it in a conspicuous place (the number of persons it can carry, as determined by) the net cubic feet contents as per ratio in the following paragraph:

Life-Raft Capacity.—All life-rafts and floats shall have an actual buoyancy of $187\frac{1}{2}$ lbs. upon oceans for every person allowed, and 156 lbs. upon lakes, bays, sounds, and rivers for every person allowed. Such life-rafts and floats must be suitably equipped with life-lines and oars.

All rubber and canvas rafts shall be kept inflated at all times.

Life-Floats.—When wooden life-floats are required on steam-vessels, in compliance with law they shall be at least of the following dimensions, or other proper dimensions of equal cubical capacity, viz., 4 feet in length, 14 inches in breadth, and 2 inches in thickness. These floats shall be made of white pine wood, or any other wood not exceeding white pine* in weight per cubic foot.

Drags, or Floating Anchors.—Drags, or floating anchors, shall be constructed so as to be capable of being compactly stowed near the head of the ship. (For a detail of these anchors, see p. 363.)

Steamers navigating the ocean must be provided with at least one drag, of area as follows:—For steamers of 400 gross tons and

* What is known as white pine in the States is called yellow pine in the *British Isles.*

under, not less than 25 superficial feet; for steamers of over 400 gross tons, the area of drag shall not be less than that determined by adding to 25 square feet one square foot for each additional 25 gross tons above 400 tons.

Example. — The area of a drag on a vessel of 1,000 tons will equal: —

$$25 + \frac{1{,}000 - 400}{25} = 49 \text{ square feet.}$$

Steamers of over 5,000 tons gross may be equipped with two or more drags, provided the total area is not less than that required by this rule. Steamers whose routes do not extend **off anchorage** are not required to have drags, or floating anchors, on board. (A table giving areas for sea-anchors based on the above rule is given on p. 362.)

Every **life-preserver** adjustable to the body of a person shall be made of good, sound cork blocks or other suitable material, with belts and shoulder straps properly attached, and shall be constructed so as to place the cork underneath the shoulders and around the body of the person wearing it, the shoulder straps to be sewed on at least eight inches apart on the back of the preserver, and sewed together at an angle where they cross the body, and must also have a strap across the breast from one shoulder strap to the other, sewed fast at one end and with a buttonhole at the other, with a button on shoulder strap to which the cross piece can be buttoned, and all belt life-preservers shall be not less than 54 inches in length, measurement from end to end around the body. And it shall be the duty of the inspectors to see by actual examination that every such life-preserver contains at least six pounds of good cork, which shall have a buoyancy of at least four pounds to each pound of cork. Inspectors are further required to see such life-preservers are distributed throughout the cabins, staterooms, berths, and other places convenient for passengers on such steamer; and there shall be a printed notice posted in every cabin and stateroom, and in conspicuous places about the decks, informing passengers of the location of life-preservers and other life-saving appliances, and of the mode of applying or adjusting the same. Cork cushions, when constructed of good, sound cork blocks or other suitable material, with belts and shoulder straps properly attached, said cushions to contain not less than six pounds of cork, when passed by local inspectors, may be used in lieu of life-preservers on small pleasure steamers.

Barges towed by steamers and carrying passengers on regular "night routes" shall have a life-preserver for each passenger; and, in addition thereto, shall be supplied with a yawl boat, ten buckets and three axes.

Every sea-going steamer and every steamer navigating the great Northern and Northwestern lakes carrying passengers shall have not less than three water-tight cross bulkheads. Such bulkheads shall reach to the main deck in single-decked vessels, otherwise to the deck next below the main deck. For wooden hulls they shall be fastened to suitable framework, which framework must be securely attached to the hull and caulked. For iron hulls they shall be well secured to the framework of the hulls and strengthened by stanchions of angle iron placed not more than two feet from centre to centre. One of the bulkheads must be placed forward and one abaft of the engines and boilers.

The third or collision bulkhead must be placed not nearer than five feet from the stem of the vessel. Iron bulkheads must be made not less than one-quarter of an inch in thickness, and wooden bulkheads must be of equal strength and covered with iron plates not less than one-sixteenth of an inch in thickness.

Steam ferry-boats of 50 tons burden and over must be supplied with life-boats as in the judgment of the inspector will best promote the security of life on board of such vessels in case of disaster, according to the average number of passengers carried per trip.

Table of dimensions of boats for passenger steamers of 100 gross tons and under, navigating lakes, bays, sounds, and rivers, other than the Red River of the North and rivers whose waters flow into the Gulf of Mexico. Boats of other dimensions of equivalent cubical capacity may be used : —

Number of Tons (Gross).	Number of Boats.	Dimensions.					Factor.	Contents.
		Length.	Breadth.		Depth.			
Steamers over :		Ft.	Ft.	In.	Ft.	In.		Cu. Ft.
50 and not over 100	1	18	5	6	2	3	.7	155.9
30 " " 50	1	16	5	6	2	3	.7	138.6
10 " " 30	1	14	5	0	2	2	.7	106.1
0 " " 10	1	14	4	6	2	0	.7	88.2

The cubical capacity of life-boats on steamers of 100 gross tons and under, navigating the Red River of the North and rivers whose

waters flow into the Gulf of Mexico, shall be as follows, measured as per example in Section 2, Rule III: —

	Cubic Feet.
Steamers over 50 and not over 100 gross tons . .	105
Steamers over 30 and not over 50 gross tons . .	92
Steamers over 10 and not over 30 gross tons . .	71
Steamers of 10 gross tons and under	60

The life-boat on steamers between 50 and 100 tons must be in addition to the working boat required by Section 6 of this rule.

The boat for passenger steamers of 10 tons and less may be dispensed with if such steamer is provided with metallic air chambers, placed under the seats and in the ends of said vessel, of sufficient capacity to float the inert weight of said vessel including her boilers and machinery; otherwise the life-boat referred to in the above table must be either carried or towed at all times when being navigated with passengers on board; and all such vessels referred to in this section shall also be provided with one life-preserver for every person which the inspection certificate shall allow them to carry, including officers and crew.

All open steam launches or other steam-vessels of five tons burden or less, used for pleasure purposes only, will not be required to carry a life-boat. Such steamers when licensed to carry passengers may dispense with the life-boat when such vessels are provided with metallic air chambers placed under the seats and in the ends of said vessels, of sufficient capacity to float the inert weight of said vessel, including her boilers and machinery; and such vessels shall also be provided with one life-preserver for every person which the inspection certificate shall allow them to carry, including the officers and crew; and every such steam-vessel carrying fifteen passengers or less shall carry at least two fire buckets and one axe.

All steam-vessels certificated as ocean, lake, bay, or sound at their annual inspection after the adoption of this rule (except vessels of 100 tons and under, inspected under the provisions of Section 4426, Revised Statutes, and freight and towing steamers, inspected under the provisions of Section 4427, Revised Statutes) shall be provided with a line-carrying projectile and the means of propelling it, such as may have received the formal approval of the Board of Supervising Inspectors.

All inland passenger steamers are required to be provided with fire buckets, barrels, axes, as follows:

Gross Tons.	Barrels.	Buckets.	Axes.
All steamers not over 10 tons . .	. . .	2	1
All steamers over 10 tons and not over 25 tons	. . .	4	1
All steamers over 25 tons and not over 50 tons	1	6	2
All steamers over 50 tons and not over 100 tons	1	8	2
All steamers over 100 tons and not over 200 tons	2	18	4
All steamers over 200 tons and not over 500 tons	4	24	6
All steamers over 500 tons and not over 1000 tons	6	35	8
All steamers over 1000 tons . .	8	50	10

For tug, tow, freight, and small ferry steamers:

Gross Tons.	Barrels.	Buckets.	Axes.
All steamers not over 10 tons . .	. . .	2	1
All steamers over 10 tons and not over 25 tons	. . .	4	1
All steamers over 25 tons and not over 50 tons	1	6	2
All steamers over 50 tons and not over 100 tons	1	8	2
All steamers over 100 tons and not over 200 tons	1	12	2
All steamers over 200 tons and not over 500 tons	2	15	3
All steamers over 500 tons and not over 1000 tons	3	20	4
All steamers over 1000 tons, not less than	4	25	5

Provided, however, That tanks of suitable dimensions and arrangements, or buckets in sufficient number may be substituted for barrels on all vessels. Five buckets shall be considered as equivalent to one barrel.

Fire buckets, barrels, or tanks, must be constantly filled with water, and in such positions on board as shall be most convenient for extinguishment of fire.

All axes must be so located as to be readily found in time of need, must not be used for general purposes, and must be kept in good condition.

All hay, straw, or baled shavings carried on deck of passenger steamers shall be covered with a tarpaulin while on board.

Boilers. — All boilers shall have a clear space of at least 8 inches between the underside of the cylindrical shell and the floor or keelson.

All boilers shall have a clear space at the back and ends thereof of 2 feet opposite the back connection door; provided, that on vessels constructed of iron or steel with metal bulkheads the distance between back connection doors and such metal bulkheads shall not be less than 16 inches.

Donkey Boiler. — Every sea-going steamer carrying passengers shall be supplied with an auxiliary or donkey boiler of sufficient capacity to work the fire pumps, and such boiler shall not be placed below the lower decks except on single-deck vessels.

CHAPTER V.

INTERNATIONAL RULES OF 1897.*

Preliminary Definitions. — In the following rules every steam-vessel which is under sail and not under steam is to be considered a sailing-vessel, and every vessel under steam, whether under sail or not, is to be considered a steam-vessel.

The word "steam-vessel" shall include any vessel propelled by machinery.

A vessel is "under way" within the meaning of these rules when she is not at anchor, or made fast to the shore, or aground.

Lights, etc. — The word "visible" in these rules when applied to lights shall mean visible on a dark night with a clear atmosphere.

The rules concerning lights shall be complied with in all weathers from sunset to sunrise, and during such time no other lights which may be mistaken for the prescribed lights shall be exhibited.

Steam-Vessel's Masthead Light. — A steam-vessel, when under way, shall carry: (*a*) On or in front of the foremast, or if a vessel without a foremast, then in the fore part of the vessel, at a height above the hull of not less than twenty feet, and if the breadth of the vessel exceeds twenty feet, at a height above the hull not less than such breadth, so, however, that the light need not be carried at a greater height above the hull than forty feet, a bright, white light, so constructed as to show an unbroken light over an arc of the horizon of twenty points of the compass, so fixed as to throw the light ten points on each side of the vessel, namely, from right ahead to two points abaft the beam on either side, and of such a character as to be visible at a distance of at least five miles.

Steam-Vessel's Side-Lights. — (*b*) On the starboard side a green light so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the starboard side, and of such a character as to be visible at a distance of at least two miles.

(*c*) On the port side a red light so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two

* Subscribed to by the Maritime Nations.

points abaft the beam on the port side, and of such a character as to be visible at a distance of at least two miles.

(*d*) The said green and red side-lights will be fitted with inboard screens projecting at least three feet forward from the light, so as to prevent these lights from being seen across the bow. (Fig. 286.)

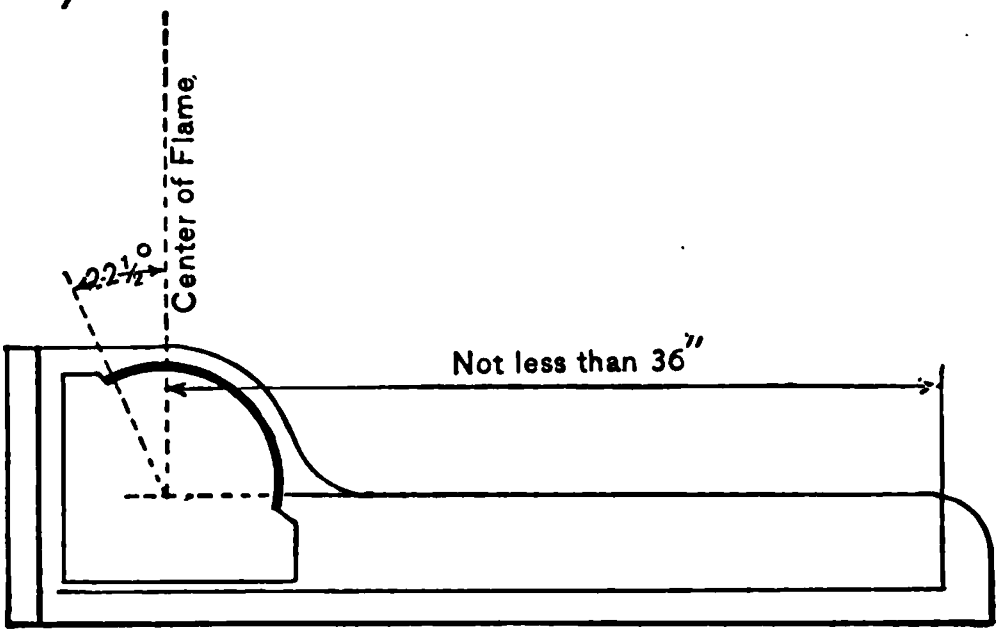


FIG. 364.

Steam-Vessels' Range Lights. — (*e*) A steam-vessel when under way may carry an additional white light similar in construction to the light mentioned in subdivision (*a*). These lights shall be so placed in line with the keel that one shall be at least fifteen feet higher than the other, and in such a position with reference to each other that the lower light shall be forward of the upper one. The vertical distance between these lights shall be less than the horizontal distance.

Steam-Vessels when Towing. — A steam-vessel when towing another vessel shall, in addition to her side-lights, carry two bright white lights in a vertical line one over the other, and not less than six feet apart; and when towing more than one vessel shall carry an additional bright white light six feet above or below such light, if the length of the tow measuring from the stern of the towing vessel to the stern of the last vessel towed exceeds six hundred feet. Each of these lights shall be of the same construction and character, and shall be carried in the same position as the white light mentioned in Article 2 (*a*), excepting the additional light, which may be carried at a height of not less than fourteen feet above the hull.

Such steam-vessels may carry a small white light abaft the funnel or aftermast for the vessel towed to steer by, but such light shall not be visible forward of the beam.

Special Lights. — (*a*) A vessel which from any accident is not under command shall carry at the same height as the white light mentioned in Article 2 (*a*), where they can be best seen, and if a steam-vessel in lieu of that light, two red lights, in a vertical line one over the other, not less than six feet apart, and of such a character as to be visible all around the horizon at a distance of at least two miles; and shall by day carry in a vertical line one over the other, not less than six feet apart, where they can be best seen, two black balls or shapes, each two feet in diameter.

(*b*) A vessel employed in laying or in picking up a telegraph cable shall carry in the same position as the white light mentioned in Article 2 (*a*), and if a steam-vessel in lieu of that light, three lights in a vertical line one over the other, not less than six feet apart. The highest and lowest of these lights shall be red, and the middle light shall be white, and they shall be of such a character as to be visible all around the horizon at a distance of at least two miles. By day she shall carry in a vertical line one over the other, not less than six feet apart, where they can be best seen, three shapes not less than two feet in diameter, of which the highest and the lowest shall be globular in shape and red in color, and the middle one diamond in shape and white.

(*c*) The vessels referred to in this article, when not making way through the water, shall not carry the side-lights, but when making way shall carry them.

(*d*) The lights and shapes required to be shown by this article are to be taken by other vessels as signals that the vessel showing them is not under command and cannot therefore get out of the way.

These signals are not signals of vessels in distress and requiring assistance. Such signals are contained in Article 31.

Lights for Sailing-Vessels and Vessels in Tow. — A sailing-vessel under way and any vessel being towed shall carry the same lights as are prescribed by Article 2 for a steam-vessel under way, with the exception of the white lights mentioned therein, which they shall never carry.

Lights for Small Vessels. — Whenever, as in the case of small vessels under way during bad weather, the green and red lights cannot be fixed, these lights shall be kept at hand, lighted and ready for use; and shall on the approach of or to other vessels, be exhibited on their respective sides in sufficient time to prevent collision, in such manner as to make them most visible, and so that the green light shall not be seen on the port side, nor the red light on the starboard side, nor, if practicable, more than two points abaft the beam on their respective sides. To make the use of these portable lights more certain and easy, the lanterns

containing them shall each be painted outside with the color of the light they respectively contain, and shall be provided with proper screens.

Lights for Small Steam and Sail Vessels and Open Boats. — Steam-vessels of less than forty, and vessels under oars or sails of less than twenty tons gross tonnage, respectively, and rowing boats, when under way, shall not be required to carry the lights mentioned in Article 2 (*a*), (*b*), and (*c*), but if they do not carry them they shall be provided with the following lights: —

First: Steam-vessels of less than forty tons shall carry: —

(*a*) In the fore part of the vessel or on or in front of the funnel, where it can be best seen, and at a height above the gunwale of not less than nine feet, a bright white light constructed and fixed as prescribed in Article 2 (*a*), and of such a character as to be visible at a distance of at least two miles.

(*b*) Green and red side-lights constructed and fixed as prescribed in Article 2 (*b*) and (*c*), and of such a character as to be visible at a distance of at least one mile, or a combined lantern showing green and red light from right ahead to two points abaft the beam on their respective sides. Such lanterns shall be carried not less than three feet below the white light.

Second: Small steamboats, such as are carried by sea-going vessels, may carry the white light at a less height than nine feet above the gunwale, but it shall be carried above the combined light mentioned in subdivision one (*b*).

Third: Vessels under oars or sails of less than twenty tons shall have ready at hand a lantern with a green glass on one side and a red glass on the other side, which, on the approach of or to other vessels, shall be exhibited in sufficient time to prevent collision, so that the green light shall not be seen on the port side, nor the red light on the starboard side.

Fourth: Rowing boats, whether under oars or sail, shall have ready at hand a lantern showing a white light which shall be temporarily exhibited in sufficient time to prevent collision.

The vessels referred to in this article shall not be required to carry the lights prescribed by Article 4 (*a*) and Article 11, last paragraph.

Lights for Pilot-Vessels. — Pilot vessels, when engaged on their station on pilotage duty, shall not show the lights required for other vessels, but shall carry a white light at the masthead, visible all around the horizon, and shall also exhibit a flare-up light or flare-up lights at short intervals, which shall never exceed fifteen minutes.

On the near approach of or to other vessels they shall have their side-lights lighted, ready for use, and shall flash or show them at

short intervals, to indicate the direction in which they are heading; but the green light shall not be shown on the port side, nor the red light on the starboard side.

A pilot vessel of such a class as to be obliged to go alongside of a vessel to put a pilot on board, may show the white light instead of carrying it at the masthead, and may instead of the colored lights above mentioned, have at hand, ready for use, a lantern with green glass on one side and red glass on the other, to be used as prescribed above.

Pilot vessels, when not engaged on their station on pilotage duty, shall carry lights similar to those of other vessels of their tonnage.

A steam pilot vessel when engaged on her station on pilotage duty and in the waters of the United States, and not at anchor, shall, in addition to the lights required for all pilot boats, carry at a distance of eight feet below her white masthead light a red light, visible all around the horizon, and of such character as to be visible on a dark night with a clear atmosphere at a distance of at least two miles, and also the colored side-lights required to be carried by vessels when under way.

When engaged on her station on pilotage duty and in waters of the United States, and at anchor, she shall carry, in addition to the lights required for all pilot boats, the red light above mentioned, but not the colored side-lights.

When not engaged on her station on pilotage duty, she shall carry the same lights as other steam-vessels.

Lights, etc., of Fishing Vessels. — (Article 9, act of August 19, 1890, was repealed by act of May 28, 1894, and Article 10, act of March 3, 1885, was re-enacted in part by act of August 13, 1894, and is reproduced here in part as Article 9. It will be the object of further consideration by the maritime powers.)

Fishing vessels of less than twenty tons net registered tonnage, when under way and not having their nets, trawls, dredges, or lines in the water, shall not be obliged to carry the colored side-lights; but every such vessel shall in lieu thereof have ready at hand a lantern with a green glass on the one side and red glass on the other side, and on approaching to or being approached by another vessel, such lanterns shall be exhibited in sufficient time to prevent collision, so that the green light shall *not* be seen on the port side, nor the red light on the starboard side.

Lights for Fishing Vessels on European Coasts. — The following portion of this article applies only to fishing vessels and boats when in the sea off the coast of Europe lying north of Cape Finisterre: —

(a) All fishing vessels and fishing boats of twenty tons net regis-

tered tonnage or upward, when under way and when not having their nets, trawls, dredges, or lines in the water, shall carry and show the same lights as other vessels under way.

(*b*) All vessels when engaged in fishing with drift-nets shall exhibit two white lights from any part of the vessel where they can be best seen. Such lights shall be placed so that the vertical distance between them shall not be less than six feet and more than ten feet, and so that the horizontal distance between them, measured in a line with the keel of the vessel, shall not be less than five feet and not more than ten feet. The lower of these two lights shall be the more forward, and both of them shall be of such a character and contained in lanterns of such construction as to show all around the horizon, on a dark night with a clear atmosphere, for a distance of not less than three miles.

(*c*) All vessels when trawling, dredging, or fishing with any kind of drag-nets, shall exhibit, from some part of the vessel where they can be best seen, two lights. One of these lights shall be red, and the other shall be white. The red light shall be above the white light, and shall be at a vertical distance from it of not less than six feet and not more than twelve feet; and the horizontal distance between them, if any, shall not be more than ten feet. These two lights shall be of such a character and contained in lanterns of such construction as to be visible all around the horizon, on a dark night with a clear atmosphere, the white light to a distance of not less than three miles. and the red light of not less than two miles.

(*d*) A vessel employed in line fishing, with her lines out, shall carry the same lights as a vessel engaged in fishing with drift-nets.

(*e*) If a vessel, when fishing with a trawl, dredge, or any kind of drag-net, becomes stationary in consequence of her gear getting fast to a rock or other obstruction, she shall show the light and make the fog signal for a vessel at anchor.

(*f*) Fishing vessels may at any time use a flare-up in addition to the lights which they are by this article required to carry and show. All flare-up lights exhibited by a vessel when trawling, dredging, or fishing with any kind of drag-net, shall be shown at the after-part of the vessel, excepting, if that vessel is hanging by the stern to her trawl, dredge, or drag-net, they shall be exhibited from the bow.

(*g*) Every fishing vessel, when at anchor between sunset and sunrise, shall exhibit a white light, visible all around the horizon at a distance of at least one mile.

(*h*) In a fog a drift-net vessel attached to her nets, and a vessel when trawling, dredging, or fishing with any kind of drag-net, and a vessel employed in line fishing with her lines out, shall, at

short intervals, to indicate the di… …e a blast with her fog-
ing; but the green light shall …
the red light on the starb…

A pilot vessel of suc… …—A vessel which is being
a vessel to put a pil… …m her stern to such last-men-
of carrying it at … …up light.
lights above me… …be shown by this article may be
with green glas… …but in such case the lantern shall
as prescribed … …screened that it shall throw an un-

Pilot ves… …of the horizon of twenty points of the
duty, shal… …points from right aft on each side of the
tonnage. … at a distance of at least one mile. Such
A ste… …as nearly as practicable on the same level as
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Anchor Lights.—A vessel under 150 feet in length, when at anchor, shall carry forward, where it can best be seen, but at a height not exceeding twenty feet above the hull, a white light, in a lantern so constructed as to show a clear, uniform, and unbroken light visible all around the horizon at a distance of at least one mile.

A vessel of 150 feet or upwards in length, when at anchor, shall carry in the forward part of the vessel, at a height of not less than twenty feet and not exceeding forty feet above the hull, one such light, and at or near the stern of the vessel, and at such a height that it shall be not less than fifteen feet lower than the forward light, another such light.

The length of a vessel shall be deemed to be the length appearing in her certificate of registry.

A vessel aground in or near a fairway shall carry the above light or lights and the two red lights prescribed by Article 4 (*a*).

UNITED STATES INLAND RULES.*

Steam-Vessels' Masthead Lights.—A steam-vessel when under way shall carry (*a*) on, or in front of the foremast, or, if a vessel without a foremast, then in the fore part of the vessel, a bright white light so constructed as to show an unbroken light over an arc of the horizon of twenty points of the compass, so fixed as to throw the light ten points on each side of the vessel,—namely, from right ahead to two points abaft the beam on either side, and of such a character as to be visible at a distance of at least five miles.

* *For all vessels navigating harbors, rivers and inland waters of the United States, except the Great Lakes.*

Steam-Vessels' Side-Lights.—(*b*) On the starboard side a green light so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the starboard side, and of such character as to be visible at a distance of at least two miles.

(*c*) On the port side a red light so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the port side, and of such a character as to be visible at a distance of at least two miles. (See Fig. 286.)

(*d*) The said green and red side-lights shall be fitted with inboard screens projecting at least three feet forward from the light, so as to prevent these lights from being seen across the bow.

Steam-Vessels' Range-Lights.—(*e*) A sea-going steam-vessel when under way may carry an additional white light similar in construction to the light mentioned in subdivision (*a*). These two lights shall be so placed in line with the keel that one shall be at least fifteen feet higher than the other, and in such a position with reference to each other that the lower light shall be forward of the upper one. The vertical distance between these lights shall be less than the horizontal distance.

(*f*) All steam-vessels (excepting sea-going vessels and ferry-boats) shall carry in addition to green and red lights required by Article 2 (*b*) (*c*), and screens as required by Article 2 (*d*), a central range of two white lights, the after light being carried at an elevation at least fifteen feet above the light at the head of the vessel. The head-light shall be so constructed as to show an unbroken light through twenty points of the compass,—namely, from right ahead to two points abaft the beam on either side of the vessel, and the after light so as to show all around the horizon.

Steam-Vessels when Towing.—A steam-vessel when towing another vessel shall, in addition to her side-lights, carry two bright white lights in a vertical line one over the other, not less than three feet apart; and when towing more than one vessel shall carry an additional bright white light three feet above or below such lights, if the length of the tow measuring from the stern of the towing vessel to the stern of the last vessel towed exceeds six hundred feet. Each of these lights shall be of the same construction and character, and shall be carried in the same position as the white light mentioned in Article 2 (*a*), or the after range-light mentioned in Article 2 (*f*).

Such steam-vessels may carry a small white light abaft the funnel or aftermast for the vessel towed to steer by, but such light shall not be visible forward of the beam.

intervals of not more than two minutes, make a blast with her fog-horn and ring her bell alternately.

Lights for an Overtaken Vessel. — A vessel which is being overtaken by another shall show from her stern to such last-mentioned vessel a white light or flare-up light.

The white light required to be shown by this article may be fixed and carried in a lantern, but in such case the lantern shall be so constructed, fitted, and screened that it shall throw an unbroken light over an arc of the horizon of twenty points of the compass; namely, for six points from right aft on each side of the vessel, so as to be visible at a distance of at least one mile. Such light shall be carried as nearly as practicable on the same level as the side-lights.

Anchor Lights. — A vessel under 150 feet in length, when at anchor, shall carry forward, where it can best be seen, but at a height not exceeding twenty feet above the hull, a white light, in a lantern so constructed as to show a clear, uniform, and unbroken light visible all around the horizon at a distance of at least one mile.

A vessel of 150 feet or upwards in length, when at anchor, shall carry in the forward part of the vessel, at a height of not less than twenty feet and not exceeding forty feet above the hull, one such light, and at or near the stern of the vessel, and at such a height that it shall be not less than fifteen feet lower than the forward light, another such light.

The length of a vessel shall be deemed to be the length appearing in her certificate of registry.

A vessel aground in or near a fairway shall carry the above light or lights and the two red lights prescribed by Article 4 (*a*).

UNITED STATES INLAND RULES.*

Steam-Vessels' Masthead Lights. — A steam-vessel when under way shall carry (*a*) on or in front of the foremast, or, if a vessel without a foremast, then in the fore part of the vessel, a bright white light so constructed as to show an unbroken light over an arc of the horizon of twenty points of the compass, so fixed as to throw the light ten points on each side of the vessel, — namely, from right ahead to two points abaft the beam on either side, and of such a character as to be visible at a distance of at least five miles.

* *For* all vessels navigating harbors, rivers and inland waters of the *United States*, except the Great Lakes.

Steam-Vessels' Side-Lights.—(*b*) On the starboard side a green light so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the starboard side, and of such character as to be visible at a distance of at least two miles.

(*c*) On the port side a red light so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the port side, and of such a character as to be visible at a distance of at least two miles. (See Fig. 286.)

(*d*) The said green and red side-lights shall be fitted with inboard screens projecting at least three feet forward from the light, so as to prevent these lights from being seen across the bow.

Steam-Vessels' Range-Lights.—(*e*) A sea-going steam-vessel when under way may carry an additional white light similar in construction to the light mentioned in subdivision (*a*). These two lights shall be so placed in line with the keel that one shall be at least fifteen feet higher than the other, and in such a position with reference to each other that the lower light shall be forward of the upper one. The vertical distance between these lights shall be less than the horizontal distance.

(*f*) All steam-vessels (excepting sea-going vessels and ferry-boats) shall carry in addition to green and red lights required by Article 2 (*b*) (*c*), and screens as required by Article 2 (*d*), a central range of two white lights, the after light being carried at an elevation at least fifteen feet above the light at the head of the vessel. The head-light shall be so constructed as to show an unbroken light through twenty points of the compass,—namely, from right ahead to two points abaft the beam on either side of the vessel, and the after light so as to show all around the horizon.

Steam-Vessels when Towing.—A steam-vessel when towing another vessel shall, in addition to her side-lights, carry two bright white lights in a vertical line one over the other, not less than three feet apart; and when towing more than one vessel shall carry an additional bright white light three feet above or below such lights, if the length of the tow measuring from the stern of the towing vessel to the stern of the last vessel towed exceeds six hundred feet. Each of these lights shall be of the same construction and character, and shall be carried in the same position as the white light mentioned in Article 2 (*a*), or the after range-light mentioned in Article 2 (*f*).

Such steam-vessels may carry a small white light abaft the funnel or aftermast for the vessel towed to steer by, but such light shall not be visible forward of the beam.

Lights for Sailing-Vessels and Vessels in Tow. — A sailing-vessel under way or being towed shall carry the same lights as are prescribed by Article 2 for a steam-vessel under way, with the exception of the white lights mentioned therein, which they shall never carry.

Lights for Ferry-Boats, Barges, and Canal-Boats in Tow. — The supervising inspectors of steam-vessels and the Supervising Inspector-General shall establish such rules to be observed by steam-vessels in passing each other, and as to the lights to be carried by ferry-boats and by barges and canal-boats when in tow of steam-vessels, not inconsistent with the provisions of this Act, as they from time to time may deem necessary for safety, which rules, when approved by the Secretary of Commerce and Labor, are hereby declared special rules duly made by local authority, as provided for in Article 30 of Chapter 802 of the Laws of 1890. Two printed copies of such rules shall be furnished to such ferry-boats and steam-vessels, which rules shall be kept posted up in conspicuous places in such vessels.

Lights for Small Vessels. — Whenever, as in the case of vessels of less than ten gross tons under way during bad weather, the green and red side-lights cannot be fixed, these lights shall be kept at hand, lighted and ready for use; and shall, on the approach of or to other vessels, be exhibited on their respective sides in sufficient time to prevent collision, in such manner as to make them most visible, and so that the green light shall not be seen on the port side, nor the red light on the starboard side, nor, if practicable, more than two points abaft the beam on their respective sides. To make the use of these portable lights more certain and easy, the lanterns containing them shall each be painted outside with the color of the light they respectively contain, and shall be provided with proper screens.

Rowing boats, whether under oars or sail, shall have ready at hand a lantern showing a white light, which shall be temporarily exhibited in sufficient time to prevent collision.

Lights for Pilot Vessels. — Pilot vessels, when engaged on their stations on pilotage duty, shall not show the lights required by other vessels, but shall carry a white light at the masthead, visible all around the horizon, and shall also exhibit a flare-up light or flare-up lights at short intervals, which shall never exceed fifteen minutes.

On the near approach of or to other vessels they shall have their side-lights lighted, ready for use, and shall flash or show them at short intervals, to indicate the direction in which they are head-

ing; but the green light shall not be shown on the port side, nor the red light on the starboard side.

A pilot vessel of such a class as to be obliged to go alongside of a vessel to put a pilot on board, may show the white light instead of carrying it at the masthead, and may, instead of the colored lights above mentioned, have at hand, ready for use, a lantern with green glass on the one side and red glass on the other, to be used as prescribed above.

Pilot vessels, when not engaged on their station on pilotage duty, shall carry lights similar to those of other vessels of their tonnage.

A steam pilot vessel when engaged on her station on pilotage duty and in waters of the United States, and not at anchor, shall, in addition to the lights required for all pilot boats, carry at a distance of eight feet below her white masthead light a red light, visible all around the horizon, and of such a character as to be visible on a dark night with a clear atmosphere at a distance of at least two miles, and also the colored side-lights required to be carried by vessels when under way.

When engaged on her station on pilotage duty and in waters of the United States, and at anchor, she shall carry, in addition to the lights required for all pilot boats, the red light above mentioned, but not the colored side-lights.

When not engaged on her station on pilotage duty, she shall carry the same lights as other steam-vessels.

Lights, etc., of Fishing Vessels.—Fishing vessels of less than ten gross tons, when under way and not having their nets, trawls, dredges, or lines in the water, shall not be obliged to carry the colored side-lights; but every such vessel shall, in lieu thereof, have ready at hand a lantern with a green glass on one side and a red glass on the other side, and on approaching to or being approached by another vessel, such lantern shall be exhibited in sufficient time to prevent collision, so that the green light shall not be seen on the port side, nor the red light on the starboard side.

All fishing vessels and fishing boats of ten gross tons or upward, when under way and when not having their nets, trawls, dredges, or lines in the water, shall carry and show the same lights as other vessels under way.

All vessels when trawling, dredging, or fishing with any kind of drag-nets or lines, shall exhibit, from some part of the vessel where they can be best seen, two lights. One of these lights shall be red, and the other shall be white. The red light shall be above the white light, and shall be at a vertical distance from it of not less than six feet and not more than twelve feet; and the horizontal distance between them, if any, shall not be more than ten feet.

These two lights shall be of such a character and contained in lanterns of such construction as to be visible all around the horizon, the white light at a distance of not less than three miles, and the red light not less than two miles.

Lights for Rafts, or Other Craft, not Provided for.—Rafts, or other water craft, not herein provided for, navigating by hand power, horse power, or by the current of the river, shall carry one or more good lights, which shall be placed in such manner as shall be prescribed by the Board of Supervising Inspectors of Steam-Vessels.

Lights for an Overtaken Vessel.—A vessel which is being overtaken by another, except a steam-vessel with an after range-light showing all around the horizon, shall throw from her stern to such last-mentioned vessel a white or a flare-up light.

Anchor Lights.—A vessel under 150 feet in length, when at anchor, shall carry forward, where it can be best seen, but at a height not exceeding twenty feet above the hull, a white light in a lantern so constructed as to show a clear, uniform, and unbroken light visible all around the horizon at a distance of at least one mile.

A vessel of 150 feet or upwards in length, when at anchor, shall carry in the forward part of the vessel, at a height of not less than twenty feet and not exceeding forty feet above the hull, one such light, and at or near the stern of the vessel, and at such a height that it shall not be less than fifteen feet lower than the forward light, another such light.

The length of a vessel shall be deemed to be the length appearing in her certificate of registry.

Special Signals.—Every vessel may, if necessary, in order to attract attention, in addition to the lights which she is by these rules required to carry, show a flare-up light, or use a detonating signal that cannot be mistaken for a distress signal.

Naval Lights and Recognition Signals.—Nothing in these rules shall interfere with the operation of any special rules made by the Government of any nation with respect to additional station and signal lights for two or more ships of war or for vessels sailing under convoy, or with the exhibition of recognition signals adopted by ship owners, which has been authorized by their respective Governments and duly registered and published.

Steam-Vessels under Sail by Day.—A steam-vessel proceeding under sail only, but having her funnel up, may carry in daytime, forward, where it can be best seen, one black ball or *shape* two feet in diameter.

CHAPTER VI.

TONNAGE.

Tonnage is a term used to define the hundredth part of the cubic capacity of the combined space enclosed by the holds and erections of vessels after making certain restrictions and deductions. When measured below the upper deck, i.e., the internal capacity of the boat from stem to stern, it is known as **under deck tonnage**; when forecastle, poop, bridge house, deck houses, hatches, etc., are added to the foregoing, it is called **gross tonnage**, which in turn becomes the **net register tonnage** after the legal allowances for the machinery spaces, crew space, and any rooms used for the ship's use proper, as carpenter shop, bo'sn's store, steering gear house, chain locker, officers' w.c's., etc., have been deducted.

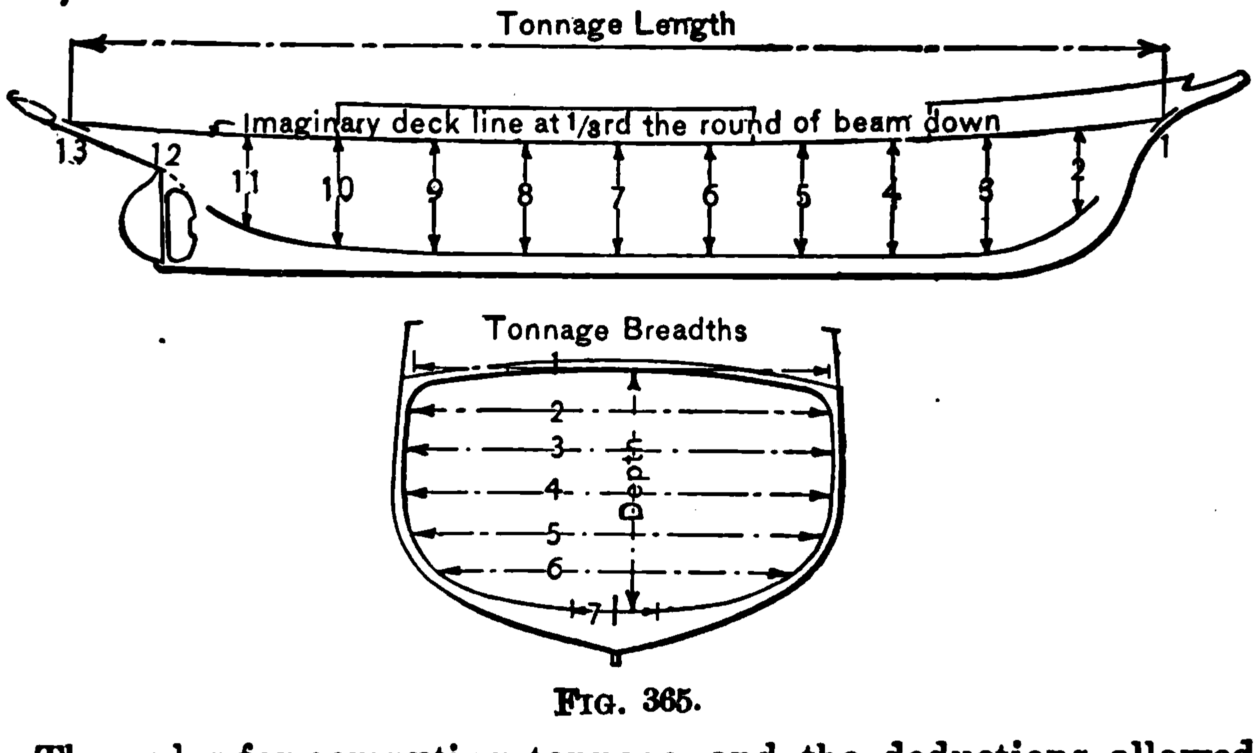

Fig. 365.

The rules for computing tonnage, and the deductions allowed, are practically the same in the legal enactments of all the principal maritime nations, although there is a slight difference in the amount of the deduction for propelling power in some of them.

All dimensions should be measured in feet and decimals of a foot, not to exceed two places, unless in the case of the one-third of the common interval, when three decimal places should be worked to.

Tonnage Deck.—The **tonnage deck** is the upper deck in all ships which have less than three decks, and the second deck from below in all other ships.

SPECIMEN SCHEDULE FOR

Ship's Name.

Length, 112.75 ft. ÷ 6 = 18.792 ft., the Common Interval between Areas.

Depths ÷ 4, the Middle Depth being Less than 16 Ft.

		Area 1.		Area 2.		Area 3.		Area 4.		Area 5.	
Depths		Feet.		Feet. 12.65		Feet. 12.3		Feet. 11.85		Feet. 11.4	
Common Interval between Breadths.				3.162		3.075		2.962		2.85	
No. of Breadths.	Multipliers	Breadths, Feet.	Products.	Breadths, Feet	Products	Breadths, Feet.	Products.	Breadths, Feet.	Products.	Breadths, Feet	Products.
1	1	..	.	19.35	19.35	20.2	20.2	20.4	20.4	20.3	20.2
2	4	.	. .	18.85	75.4	20.4	81.6	20.5	82.0	20.35	81.4
3	2			16.65	33.3	20.15	40.3	20.25	40.5	20.0	40.0
4	4			11.85	47.4	19.6	78.4	19.85	79.4	17.8	71.2
5	1	.	. .	1.85	1.85	3.0	3.0	6.35	6.35	6.35	6.35
				177.3		223.5		228.65		219.15	
*$\frac{1}{3}$ of Common Interval between Breadths.				1.05 *		1.03		.99		95	
				8865		6705		205785		109575	
				17730		22350		205785		197235	
				186.165		230.205		226.363		208.192	
		Area 1		Area 2		Area 3.		Area 4.		Area 5.	

TONNAGE CALCULATIONS.

Area 6.		Area 7.	
Feet. 10.9		Feet. . . .	
2.725		. . .	
Breadths, Feet.	Products.	Breadths, Feet	Products.
19.10	19.1	. .	. .
18.65	74 6	. .	. .
14.95	29 9	. .	. .
8.75	35.0	. .	. .
1.0	1.0	. .	. .
159 6 .91 1596 14364 145 236			
Area 6.		Area 7.	

Cubic Content and Register Tonnage.

No. of Areas.	Multipliers.	Areas Brought up, Sq. Ft.	Products.
1	1	0	0
2	4	186.17	744.68
3	2	230.21	460.42
4	4	236.36	905.44
5	2	208.19	416.38
6	4	145.24	580.96
7	1	0	0

Tonnage of Poop or Other Closed-in Space.

Break of Deck.

Mean Length, 32.15 Ft.

Common Interval between Breadths, 16.075 Ft.

No. of Breadths.	Multipliers.	Breadths, Feet.	Products.
1	1	20.0	20.0
2	4	18.6	74.4
3	1	17.16	17.15

111.55
5.36 { $\frac{1}{3}$ of com. inter. betw. breadths.
66930
33465
55775
597.91
2 – ht. of break
Cu. ft. 1,195.82 ÷ 100 = 11.96 reg. T.

3107.88 *
6.28 { $\frac{1}{3}$ of common interval between areas.
1864728
621576
1864728
19455.92 ÷ 100
= 194.55 reg. T. under deck.
11 96 break of deck as above.
206.51 gross tonnage.

Length for Tonnage.—The length at the tonnage deck in all cases of the usual sheer is to be taken on the upper surface of the deck to the inside of the stringer angle bar at stem and stern, the length so obtained being subdivided into an equal number of parts as under:—

Subdivision of Tonnage Length per British Law.

Class I. Length of 50 feet and under, 4 equal parts.
Class II. Length above 50 feet to 120 feet, into 6 equal parts.
Class III. Length above 120 feet to 180 feet, into 8 equal parts.
Class IV. Length above 180 feet to 225 feet, into 10 equal parts.
Class V. Length above 225 feet and upwards, into 12 equal parts.

Subdivision of Tonnage Length per American Law.

Class I. Length of 50 feet and under, into 6 equal parts.
Class II. Length above 50 feet to 100 feet, into 8 equal parts.
Class III. Length above 100 feet to 150 feet, into 10 equal parts.
Class IV. Length above 150 feet to 200 feet, into 12 equal parts.
Class V. Length above 200 feet to 250 feet, into 14 equal parts.
Class VI. Length above 250 feet, into 16 equal parts.

The stations at these subdivisions are the points at which the areas are calculated, and are numbered from forward aft, the foremost being numbered one, making the last ordinate in each case an odd number.

Depths.—The depths are taken at each point of division as above, from the under side of tonnage deck to the ceiling at inner edge of limber strake, deducting therefrom one-third of the beam-camber; the depths so taken are to be divided into four equal parts if the midship depth does not exceed 16 feet, otherwise into six equal parts. (See Fig. 287.)

Breadths.—These are measured off at each point of the vertical *division* of the depth as described, to the inner edge of the

side ceiling. In the case of vessels having no ceiling or sparring, the breadths must be taken to the inner edge of frame-bars.

The lower breadth, when the vessel has no horizontal flat or floor, is limited to the distance between the two limber strakes, and in flat-floored vessels to the extent of the horizontal flatness.

Where the ceiling varies in thickness on the sides, as in crossing a keelson or stringer, or at dumping pads, the **average** thickness should be taken. (See Fig. 287.)

Sections for Areas. — When the sections have been prepared in accordance with the foregoing, the half-breadths may be measured off and tabulated in the manner shown in the accompanying table, and integrated by means of Simpson's first rule to determine the under-deck tonnage.

The erections, hatches, and shelter-deck, 'tween decks (if any), may now be calculated in detail, and added to the under-deck tonnage to obtain the gross.

Engine Room Deduction. — The **actual** space enclosed by the engine room must be calculated, and the percentage it bears to the gross tonnage determined to enable the **allowance** conceded by law to be made. Should this percentage be over thirteen and under twenty, an allowance of thirty-two per cent may be deducted from the gross tonnage in computing the **net register**, or the tonnage on which a ship's dues are usually paid.

Should, however, the actual engine room not exceed thirteen per cent of the gross tonnage, the allowance would then be the actual space plus $\frac{3}{4}$ of same.

It should be noted that the gross tonnage is the same whether the vessel is a steamer or a sailing ship.

Tonnage Deductions. — All spaces which have been measured and deducted from the gross tonnage, as officers' rooms, crew's forecastle, chain-locker, chart-house, etc., must be properly marked over the door by having the certification cut in, and also inside, on a beam or other conspicuous place.

MARKING OF SHIP.

Name. — The vessel's name must be marked on each bow, and the name and port of registry on the stern, on a dark ground, in white or yellow letters, or on a light ground in black letters. The letters should preferably be black, and not less than 4 inches long.

In addition, ships of American registry must have their name cut in large name boards fitted on each side of top of pilot house, with letters not less than 6 inches high.

Official Number and Tonnage. — The official number and the net registered tonnage must be cut in on the main beam or the 'thwartship coaming of main hatch.

Draught Marks. — A scale of feet denoting the draught of water must be cut in on each side of the stem and stern-post from one foot below light line to about two feet above deep load draught. These should be in Roman letters or figures, 6 inches long, the **lower** line of such letters or figures to coincide with the draught line indicated. The figures, after being cut in, should be painted white or yellow on a dark ground.

Space for Seamen. — In arranging crew's quarters, care must be taken that a minimum capacity of 72 cubic feet is allowed for each seaman, and a clear floor space of not less than twelve square feet.

NEW YORK YACHT CLUB RACING RULES.

Rating Formula. — Yachts shall be rated for classification and time allowance according to the following formula: —

$$\text{Rating measurement} = \frac{L\sqrt{SA}}{5\sqrt[3]{D}} \left\{ \begin{array}{l} \text{Length multiplied by square} \\ \text{root of sail area divided by} \\ \text{5 times cube root of dis-} \\ \text{placement.} \end{array} \right.$$

The result is the measurement for classification and time allowance.

Length. — The mean of the length over all, exclusive of bulwarks and rail, and of the length on the load water plane, both measurements to be taken parallel to the middle vertical plane, and at a distance from it equal to one-quarter ($\frac{1}{4}$) of the greatest beam at the load water line.

In case the width of the stern on deck exceeds one-half ($\frac{1}{2}$) the greatest beam at the load water line, the measurement for the length over all shall be taken to a point abaft the stern, where the continuation of the fair line of the top edge of the plank-sheer would intersect the quarter beam line.

Sail Area. — Sail area to be obtained as follows, and the square root of this area to be the $\sqrt{SA}$ in formula: —

Mainsail. — *A*. Measured from the top of the boom (under the pin for outhaul shackle on traveller, or clew slide, when hauled chock out) to the gaff under the pin of the sheave of the topsail sheet, provided the peak cringle of the mainsail does not extend beyond the pin; in the case of the yacht having no top-

sail, or of the peak cringle extending beyond the pin of the topsail-sheet sheave, the measurement to be taken to the peak lacing-hole.

B. Perpendicular to *A*, measured to underside of gaff close in to the mast.

C. Measured from top of boom over the pin of the sheave or outhaul or end of clew slide to underside of gaff close in to the mast.

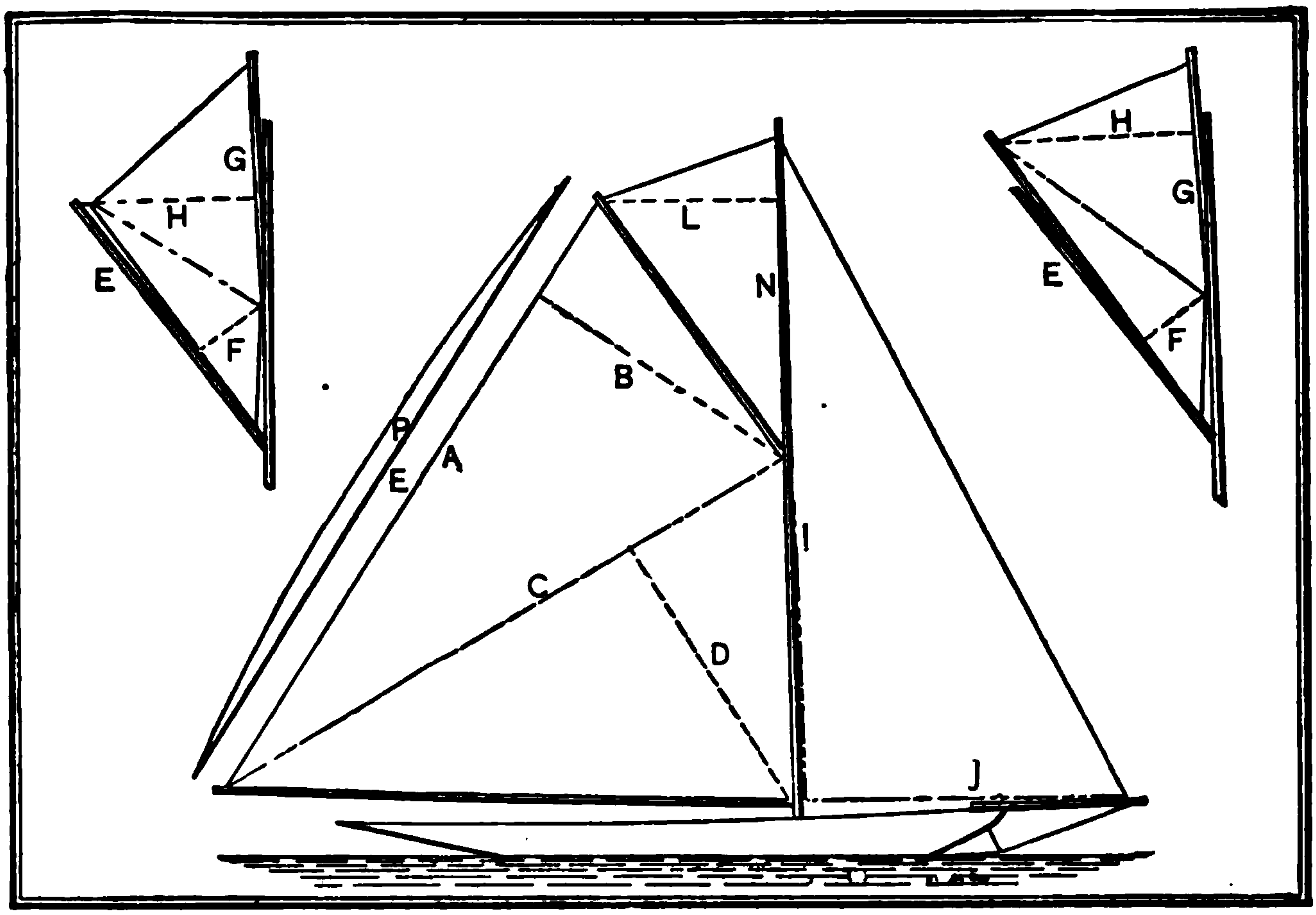

FIG. 366.

D. Perpendicular to *C*, measured in to the mast, in a line with the top of the boom, or to tack cringle of mainsail, if below top of boom.

Club Topsail.—*E*. Measured from upper side of gaff close in to the mast to pin of sheave for topsail sheet, or to lacing-hole in club.

F. Perpendicular to *E*, measured to lower lacing-hole in sprit.

G. From lacing-hole to lacing-hole in sprit.

H. Perpendicular to *G*, measured to pin of sheave for topsail sheet in gaff; or to upper lacing-hole in club.

Jib Header.—*K*. Measured from top of gaff close in to mast to pin of halyard sheave in topmast.

L. Perpendicular to *K*, measured to pin of topsail sheet sheave in gaff; or to upper lacing-hole in club.

Lugsail. — To be measured as mainsail, except as follows: —

A. Upper end measured to peak lacing-hole in yard.

B and *C*. Forward end measured to lower lacing-hole in yard.

D. Lower end measured to tack cringle of mainsail, if below top of boom, or forward of mast.

Headsails. — *I*. The perpendicular *I* to be measured from the deck, at the foreside of the mast to where the line of the luff of the foremost headsail, or of the spinnaker halyard, as the case may be, when extended, cuts such perpendicular. In the case of a schooner the perpendicular *I* shall be measured upon the foremast, unless she has a main spinnaker, the height of which exceeds the perpendicular upon the foremast, in which case the excess shall be added to the perpendicular *I*.

J. The base *J* to be measured from the foreside of the mast to where the line of the luff of the foremost headsail, when extended, cuts the bowsprit, other spar, hull, etc., as the case may be. In all cases, if the distance from the centre fore-and-aft line of the mast to the outer end of the spinnaker boom exceeds the distance from the foreside of the mast to the bowsprit end (where cut by the line of the luff of the foremost headsail) the excess shall be added to the base of the fore triangle.

In the case of a schooner, the base *J* shall be measured from the foremast, but if the main or longest spinnaker boom exceeds the before-mentioned distance, the excess shall be added to the base *J*.

In the case of a yacht having no headsail, but carrying a spinnaker, the area for headsail shall be computed from the length of spinnaker boom, and the height from deck to where the line of the halyard of the spinnaker when extended cuts the mast.

A spinnaker may have a headstick, or board, not longer than one-twentieth the length of the spinnaker boom, but not a foot-yard, or more than one sheet, or any other contrivance for extending the sail to other than a triangular shape.

In the case of a yacht carrying a square sail, or square topsail, or raffee (together or separately), the actual area of the same shall be computed; and if such area exceed the area of the fore triangle, the excess shall be used in the total area for determining the rating.

Foresail of Schooners. — To be measured as mainsail, except that the lower end of *A* is to be taken at foreside of mainmast, in a line with main boom gooseneck.

Directions for Measuring Sails. — The measurer shall take measurements *I* and *J* for fore triangle, *G* and *E* for club topsail, *and the length* of spinnaker boom. If the other measurements

are supplied by the sailmaker, the measurer shall check them by measuring the following:—

Boom,—from lower end of *A* to lower end of *D*.

Gaff or lug yard,—from upper end of *A* to forward end of *B*.

Club Topsail,—sheet to outer lacing-hole.

In cases where it is necessary for the official measurer to measure the sails, he shall do so in the following manner: Take the length of boom from mast to pin of sheave for outhaul, and length of gaff from mast to pin of topsail sheet sheave or lacing-hole, as the case may require; then hoist the sail with the tack fast and set the peak and luff up taut, and let go the topping lifts so that the weight of the boom comes on the leach of the sail. With a line and tape, measure the leach and luff and the diagonal *C*. For the headsail measure the height *I* and the distance *J*, as provided for in the section dealing with headsail. For topsail the sail should be hoisted and marked in a line with the gaff; then lowered and the other dimensions taken. From the measurements so taken a sail plan should be made and the other above-specified measurements obtained therefrom.

CALCULATION OF SAIL AREAS.

Mainsail.—Multiply *A* by *B* and *C* by *D*, and add the two products together and divide by 2.

Yard Topsail.—Multiply *E* by *F* and *G* by *H*, and add the two products together and divide by 2.

Jib Header.—Multiply *K* by *L* and divide by 2.

Headsails.—Multiply *I* by *J* and divide by 2.

Lugsails and Headsails.—No deduction is to be made from headsail area on the score of any portion of the lugsail area ahead of the mast.

Sails Bounded by Curved Edges.—Any increase in the area of sails due to curved edges, extended by battens, or otherwise, beyond the line between the points for measurement, shall be computed as follows: Multiply the base *E* by two-thirds of the perpendicular *P*.

Displacement.—*D*. Displacement to be obtained as follows: At points dividing the length of the load water line into five equal parts, find areas of immersed cross sections in square feet; from the areas in square feet obtained and load water line length, find approximate displacement in cubic feet, which will be the *D* in formula.

Limit of L.W.L.—One half (½) of any excess of L.W.L. over one hundred and fifteen per cent (115%) of *L* shall be added to the rating measurement.

The L.W.L. shall be the distance in a straight line between the points farthest forward and farthest aft, where the hull, exclusive of the rudder post, is intersected by the surface of the water when the yacht is afloat, in racing trim.

Limit of Draught.—Limit of draught in feet = .133 (rating measurement) + 2.66.

Any excess of draught, exclusive of centre-board, as per above formula, shall be multiplied by five (5) and added to the rating measurement.

The draught of any vessel, exclusive of centre-board, shall not exceed eighteen (18) feet.

Limit of Sail Area.—Any excess of the square root of sail area over one hundred and thirty-five per cent (135%) of *I* shall be added to the rating measurement.

All measurements of hull shall be taken with only such persons on board as shall be required by the measurer.

All measurements specified may be certified to by the designer, in a certificate to be filed with the measurer of the club, but such certificate must be accompanied by drawings, showing the measurements taken, and the true line of flotation of the vessel when measured in racing trim, which measurement and line of flotation must be verified by the measurer, before any certificate of measurement shall be accepted by the secretary.

If from any peculiarity in the build of a yacht, or other cause, the measurer shall be of opinion that the rule will not rate the yacht fairly, or that in any respect she does not comply with the requirements of these rules, he shall report the circumstances to the Regatta Committee, who, with the measurer, after due inquiry, shall award such a certificate of rating as they may consider equitable, and the measurement shall be deemed incomplete until this has been done.

CLASSIFICATION.

Schooners.—Class *A*. All over 100 feet, rating measurement.

Class *B*. Not over 100 feet and over 80 feet, rating measurement.

Class *C*. Not over 80 feet and over 64 feet, rating measurement.

Class *D*. Not over 64 feet and over 51 feet, rating measurement.

Class E. Not over 51 feet, rating measurement.

Single-masted Vessels and Yawls. — Class *F*. All over 100 feet, rating measurement.

Class *G*. Not over 100 feet and over 80 feet, rating measurement.

Class *H*. Not over 80 feet and over 64 feet, rating measurement.

Class *I*. Not over 64 feet and over 51 feet, rating measurement.

Class *J*. Not over 51 feet and over 40 feet, rating measurement.

Class *K*. 40 feet and under, rating measurement.

Sails. — Yachts in races may carry the following sails: —

Schooners. — Mainsail, foresail, fore staysail, jib, flying-jib, jib-topsail, fore and main gaff topsail, maintopmast staysail, and spinnaker.

Sloops and Cutters. — Mainsail, fore staysail, jib, flying-jib, jib-topsail, gaff topsail, and spinnaker.

Yawls. — Same as sloops and cutters, with mizen and mizen-staysail.

Balloon Sails. — Yachts may set light sails over working sails.

Boats and Life-Buoys. — All yachts shall carry at least two serviceable life-buoys on deck ready for use.

Classes *A* and *B* of schooners, and *F* and *G* of single-masted vessels and yawls, shall carry on deck a serviceable round-bottom boat, not less than 14 feet in length; and classes *C* and *D* of schooners, and *H* and *I* of single-masted vessels and yawls, a boat as above, not less than 12 feet in length; and in classes *E* of schooners, and *J* and *K* of single-masted vessels and yawls, a boat as above, not less than 10 feet in length. All boats to have oars and rowlocks or tholepins lashed in.

Bulkheads, Ballast, etc. — Floors must be left down and bulkheads and doors left standing; water-tanks kept in place, and at least one bower anchor and cable kept on board. All yachts, except in classes *A* of schooners and *G* of single-masted vessels and yawls, shall keep their galley fixtures and fittings on board and in their proper places. Trimming by dead-weight shall not be allowed after the preparatory signal. Neither ballast nor water shall be taken in or discharged after 9 P.M. of the day before a race, but the above restriction may be waived as to water, only by permission.

Crew. — The number of men permitted on a yacht during a race shall not exceed that given by the following table: —

Classes *A* and *F*. One man for every 250 square feet of sail area, or fraction thereof.

Classes *B*, *C*, *D*, *E*, *G*, *H*, *I*, *J*, and *K*. One man for every 300 square feet of sail area, or fraction thereof.

BUILDERS' OLD MEASUREMENT TONNAGE

This tonnage, commonly called B. O. M., is still much in vogue with yacht builders, but obsolete otherwise.

$$\text{B.O.M.} = \frac{(L - \frac{3}{5}B) \times B \times \frac{1}{2}B}{94},$$

where *L* is the length of vessel measured along top of keel from after side of stern post, to the intersection of a perpendicular with the fore part of stem under the bowsprit, and *B* is the extreme breadth to outside of planking, exclusive of doublings.

THAMES MEASUREMENT TONNAGE.

This rule was formulated by the Royal Thames Yacht Club, and is much used for the measurement of yachts.

$$\text{T.M.} = \frac{(L - B) \times B \times \frac{1}{2}B}{94},$$

where *L* is the length measured in a straight line at the deck from the fore part of stem to the after part of stern post, and *B* is the extreme breadth to outside of planking.

SECTION VI.

WEIGHT OF A CUBIC FOOT OF SUBSTANCES.

NAME OF SUBSTANCES.	POUNDS
A.	
Acacia	44.4
Alder	34.6
Aluminum, cast	160
Aluminum, sheet	168
Aluminum, bronze	478
Alum	107
Antimony	417
Anthracite coal, broken, cubic foot averages	54
A ton, loose, occupies 40–43 cubic feet.	
Apple wood	49.5
Air	0.08
Ash (American)	39
Asphalte	156
Asbestos Board $\frac{1}{8}''$ thick, per square foot	65
B.	
Barley	38
Basalt	170
Babbit, white brass	456
Beech	43.8
Bell, metal	502.5
Birch	33
Bismuth	608
Bitumastic solution per gallon	9
Bituminous coal, broken, cubic foot averages	49
A ton, loose, occupies 43–48 cubic feet.	
Box wood	62.5
Brick, best pressed	150
Brick, common hard	125
Brick, soft inferior	100
Brickwork, pressed brick	140
Brickwork, ordinary	112
Brass, common	525–530
Brass, wire	533
Bronze	544

Name of Substances.	Pounds.
C.	
Camphor	62
Cedar, American red	30.8
Cedar, white	23
Cement, hydraulic, ground, loose, American	56
Cement, hydraulic, ground, loose, English, Portland	90
Cement and sand (3 to 1)	130
Cement, hydraulic, Louisville, bushel =	62
Cement, hydraulic, Portland, bushel =	96
Cement, Roman	100
Charcoal	183
Cherry	42
Chalk	183
Chestnut	41
Clay	119
Clay, in lump, loose	63
Coral	168
Cork	15.6
Copper	554
Coal, bituminous, solid	84
Coal, bituminous, broken, loose	49
Coal, bituminous, heaped bushel, loose	74
Coke, loose, of good coal	62
Coke, loose, heaped bushel	40
Cypress	41
D.	
Deals, Riga	43
E.	
Earth, common loam, dry, loose	76
Earth, common loam, dry, moderately rammed	95
Ebony	79.4
Elder	43.4
Elm, English	35
Emery	251
Elm, Canada	45
F.	
Felspar	168
Fir (see Red Pine, etc.)	31–41
Flagging	168
Flint	164
Freestone	153

Name of Substances.	Pounds.
G	
Granite	164
Graphite	137
Glass, flint	192
Glass, crown	157
Glass, plate	172
Gold, pure cast	1,200
Gold, standard	1,106
Gneiss	168
Greenheart	62.5
Gunmetal	534
Gum wood	37
Gypsum	143
Gypsum, ground, bushel =	70
H.	
Hay (compact, old)	8
Hawthorn	56.8
Hazel	53.7
Hemlock	25
Hornbeam	47.4
I.	
Ice	58.7
India-rubber	58
Iron, cast (average)	450
Iron, wrought, purest	485
Iron, wrought, average	480
Ironwood	71
Ivory	114
J.	
Jackwood	42
L.	
Laburnum	57.4
Larch	31.0
Lancewood	42.1
Lead, cast	708.5
Lead, sheet	711.5
Lignum-vitæ	83.2
Lime, quick, ground, loose, or in small lumps	53
Lime, quick, ground, loose, thoroughly shaken	75
Lime, quick, ground, loose, struck bushel	66
Limestones	188

Name of Substances.	Pounds
Limestones, loose, in irregular fragments	96
Lime, loose, bushel =	70
Lime, well shaken, bushel =	80
Lime wood	35
Linoleum, ¼″ thick (incl. cement) per sq. ft.	1.5
M.	
Mahogany, Spanish	53
Mahogany, Honduras	35
Marble	170
Maple	49
Masonry, of granite or limestone, well dressed	165
Masonry, of dry rubble, well scabbled	138
Masonry, of sandstone, well dressed	144
Mercury, fluid	849
Mercury, solid	977
Mica	183
Mortar, hardened	103
Muntz metal	511
N.	
Nickel (hammered)	541
Nickel (cast)	516
Nitric Acid	79.4
O.	
Oak, British	58
Oak, Riga	43
Oak (American, red, black or yellow)	45
Oak (American, white)	50
Oil (linseed)	58
Oil (olive)	57
Oil (petroleum)	48–58
Oil (whale)	58
Ore (red iron)	327
Ore (brown)	245
Ore (Clydesdale)	191
Oregon Pine (Douglas Spruce)	32
P.	
Paper (building) per roll of 400 sq. ft.	52
Petroleum, standard refined	57.75
Petroleum, Texas	58.
Phosphor Bronze	537
Pitch	69

Name of Substances.	Pounds.
Pitch pine (U. S. yellow pine)	41
Pine (long leafed Georgia yellow pine)	38
Platinum	1,414
Plumbago	140
Poplar	32
Pewter	703
Q.	
Quartz	163–169
S.	
Salt, coarse	45
Sand, of pure quartz, dry, loose	90–106
Sand, well shaken	99–117
Sand, perfectly wet	120–140
Sandstones (fit for building)	151
Satinwood	60
Snow, freshly fallen	5–12
Snow, moistened and compacted by rain	15–50
Shingle	88
Silver (standard)	644
Slate	178
Spruce, Northern	26
Spruce, Southern	30
Steel	490
Steel, cast	493
Sycamore	36.8
T.	
Tallow	59
Tar	63
Talc	168
Teak Burmese	46
Tile, common	113
Tiling, inlaid rubber, per sq. ft.	2
Tiling, vitrified brick, $1\frac{1}{4}$ thick, per sq. ft.	9
Tiling, white, $\frac{7}{16}$ in. thick, per sq. ft.	5
Tin	462
Type metal	653
Trap	170
W.	
Walnut, black	38
Water, pure rain or distilled, at 60° F.	$62\frac{1}{3}$

Name of Substances.	Pounds.
Water, salt	64
Wheat	48
Willow	25.3
White Pine (called yellow pine in England)	24
White metal, Babbitt	456
Y.	
Yew	50.3
Z.	
Zinc, rolled	449
Zinc, cast	437

WEIGHT OF SAIL CANVAS.

Canvas, No.	0	1	2	3	4	5	6	7	8
Lbs. per Sq. Ft.	.205	.197	.184	.171	.154	.141	.128	.113	.104

OIL FUEL CHART.

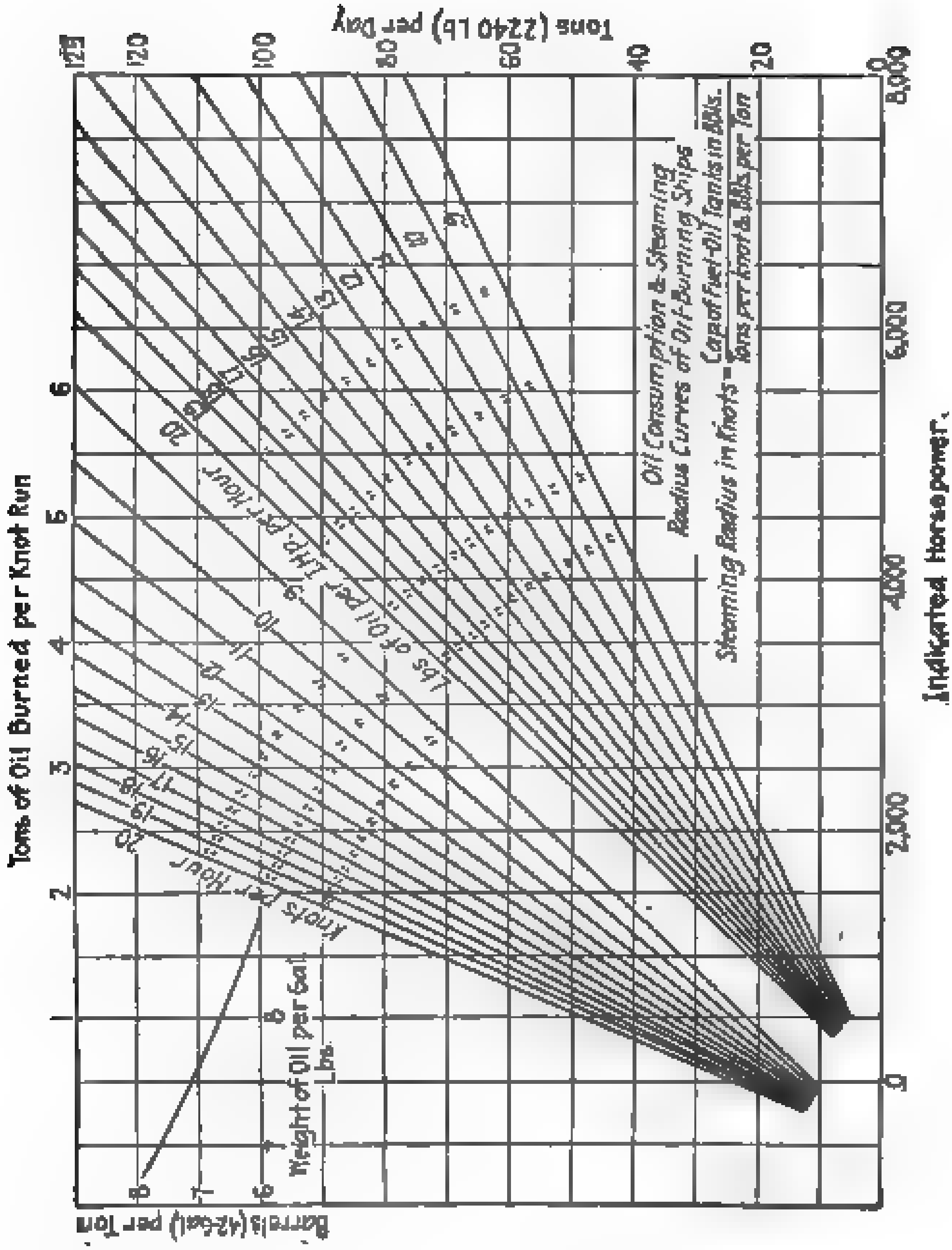

FIG. 367.

DATA FOR FUEL OIL.

Specific Gravity.	°Be.	Weight in Lbs. per Gal.	Weight in Lbs. per Bbl.	Weight in Lbs. per Cu. Ft.	Cu. Ft. per Ton.	Gallons per Ton.	Barrels per Ton.
1.0000	10	8.33	349.86	62.355	35.9	268.9	6.43
0.9929	11	8.27	347.34	61.912	36.1	270.8	6.46
0.9859	12	8.21	344.82	61.475	36.5	272.8	6.50
0.9722	13	8.16	342.72	61.045	36.7	274.6	6.54
0.9790	14	8.10	340.20	60.621	36.9	276.6	6.59
0.9655	15	8.04	337.68	60.202	37.2	278.6	6.65
0.9589	16	7.99	335.58	59.792	37.5	280.3	6.69
0.9523	17	7.93	333.06	59.380	37.7	282.4	6.73
0.9459	18	7.88	330.96	58.981	38.1	284.2	6.77
0.9395	19	7.83	328.86	58.582	38.3	286.0	6.82
0.9333	20	7.78	326.76	58.195	38.5	287.9	6.86
0.9271	21	7.72	324.24	57.809	38.8	290.0	6.91
0.9210	22	7.67	322.14	57.428	39.0	292.0	6.96
0.9150	23	7.62	320.04	57.053	39.2	293.9	7.01
0.9090	24	7.57	317.94	56.680	39.5	295.7	7.06
0.9032	25	7.53	316.26	56.319	39.8	297.4	7.09
0.8974	26	7.48	314.16	55.957	40.1	299.4	7.14
0.8917	27	7.43	312.06	55.601	40.3	301.4	7.18
0.8860	28	7.38	309.96	55.149	40.6	303.5	7.24
0.8805	29	7.34	308.28	54.903	40.8	305.2	7.28
0.8750	30	7.29	306.18	54.560	41.1	307.2	7.32
0.8484	35	7.07	296.94	52.991	42.4	316.8	7.55
0.8235	40	6.86	288.12	51.349	43.7	326.3	7.78

The above table is based on the formula $\frac{140}{130 + {}^\circ \text{Be.}} = \text{Sp. Gr.}$

For each 10° F. above 60° F. add 0.7° Be.
For each 10° F. below 60° F. subtract 0.7° Be.
42 gals. = 1 bbl. 1 ton = 2240 lbs.

WEIGHT AND STOWAGE OF OIL.

(Petroleum.)

Weight Pounds per Gallon.	Pounds per Cubic Foot.	Cubic Feet per Ton.	Gallons per Ton.
6.50	48.63	46.06	344.6
6.55	49.05	45.67	342.0
6.60	49.38	45.36	339.4
6.65	49.75	45.02	336.8
6.70	50.13	44.68	334.3
6.75	50.50	44.36	331.9
6.80	50.88	44.03	329.4
6.85	51.25	43.71	327.0
6.90	51.62	43.39	324.6
6.95	52.00	43.07	322.3
7.00	52.36	42.78	320.0
7.05	52.75	42.46	317.8
7.10	53.12	42.17	315.5
7.15	53.50	41.87	313.2
7.20	53.86	41.59	311.1
7.25	54.24	41.30	309.0
7.30	54.61	41.01	306.9
7.35	54.99	40.73	304.8
7.40	55.37	40.46	302.7
7.45	55.74	40.19	300.7
7.50	56.11	39.92	298.6
7.55	56.48	39.66	296.6
7.60	56.85	39.40	294.7
7.65	57.23	39.14	292.8
7.70	57.61	38.88	290.9
7.75	57.99	38.63	289.0
7.80	58.36	38.39	287.2
7.85	58.73	38.14	285.3
7.90	59.10	37.90	283.5
7.95	59.47	37.66	281.7
8.00	59.85	37.42	280.0

WHITWORTH STANDARD BOLTS AND NUTS.

(Dimensions are Given to the Nearest 1/64 Inch.)

Diameter of Bolt	Bolt Head and Nuts.			Threads per Inch.	Size of Split-pins L.S.G.	Diameter of Tapping Hole.
	Width across Flats.	Width across Corners.	Height of Bolt Head.			
"	"	"	"	"	No.	"
3/16	7/16	1/2 and 1/64	1/8 and 1/32	24	15	1/8 and 1/64
1/4	1/2 and 1/64	9/16 " 3/64	3/16 " 1/32	20	14	3/16
5/16	9/16 " 3/64	11/16	1/4 " 1/64	18	14	1/4
3/8	11/16 " 1/64	13/16	5/16 " 1/64	16	13	1/4 " 3/64
7/16	13/16 " 1/64	15/16 " 1/64	3/8	14	13	5/16 " 3/64
1/2	7/8 " 1/32	1 1/16	7/16	12	12	3/8 " 1/32
9/16	1 " 1/64	1 1/8 " 3/32	7/16 " 3/64	12	12	7/16 " 1/32
5/8	1 " 3/32	1 1/4 " 1/64	1/2 " 3/64	11	11	1/2 " 1/64
11/16	1 3/16 " 1/64	1 3/8 " 1/64	9/16 " 1/32	11	11	9/16 " 1/64
3/4	1 1/4 " 3/64	1 1/2	5/8 " 1/32	10	10	5/8
13/16	1 3/8 " 1/64	1 9/16 " 1/32	11/16 " 1/64	10	10	11/16
7/8	1 7/16 " 3/64	1 11/16 " 1/64	3/4 " 1/64	9	9	11/16 " 3/64
15/16	1 9/16 " 1/64	1 13/16 " 1/64	13/16	9	9	3/4 " 3/64
1	1 5/8 " 3/64	1 15/16 " 1/64	7/8	8	8	13/16 " 1/32
1 1/8	1 13/16 " 3/64	2 1/8 " 1/32	15/16 " 3/64	7	7	15/16 " 1/64
1 1/4	2 " 3/64	2 5/16 " 3/64	1 1/16 " 1/32	7	6	1 1/16
1 3/8	2 3/16 " 1/32	2 1/2 " 3/64	1 3/16 " 1/64	6	5	1 1/8 " 3/64
1 1/2	2 3/8 " 1/32	2 3/4 " 1/32	1 5/16	6	4	1 1/4 " 3/64
1 5/8	2 9/16 " 1/64	2 15/16 " 1/32	1 3/8 " 3/64	5	3	1 3/8
1 3/4	2 3/4	3 3/16	1 1/2 " 1/32	5	2	1 1/2
1 7/8	3 1/16	3 7/16 " 3/64	1 5/8 " 1/64	4 1/2	1	1 9/16 " 1/32
2	3 1/8 " 1/32	3 5/8	1 3/4	4 1/2	1	1 11/16 " 1/32
2 1/4	3 1/2 " 3/64	4 1/16 " 1/32	1 15/16 " 1/32	4	3/16	1 15/16
2 1/2	3 7/8 " 1/16	4 7/16 " 3/64	2 3/16	4	5/16	2 3/16
2 3/4	4 3/16	4 13/16 " 1/64	2 3/8 " 1/32	3 1/2	1/4	2 3/8 " 1/32
3	4 1/2 " 1/32	5 3/16 " 3/64	2 5/8	3 1/2	3/8	2 5/8 " 1/64
3 1/4	4 13/16 " 3/64	5 9/16 " 1/32	2 13/16 " 1/64	3 1/4	3/8	2 13/16 " 3/64
3 1/2	5 1/8 " 3/64	5 15/16 " 3/64	3 1/16	3 1/4	7/16	3 1/8
3 3/4	5 1/2 " 3/64	6 3/8 " 1/32	3 1/4 " 1/32	3	7/16	3 5/16 " 1/64
4	5 15/16 " 1/64	6 7/8	3 1/2	3	1/2	3 9/16 " 1/64
4 1/4	6 3/8	7 5/16 " 3/64	3 11/16 " 1/64	2 7/8	1/2	3 3/4 " 3/64
4 1/2	6 13/16 " 1/64	7 7/8	3 15/16	2 7/8	9/16	4 " 3/64
4 3/4	7 1/4 " 3/64	8 7/16	4 1/8 " 1/32	2 3/4	9/16	4 1/4 " 1/32
5	7 3/4 " 3/64	9 " 1/64	4 3/8	2 3/4	5/8	4 1/2 " 1/32
5 1/2	8 13/16 " 1/32	10 3/16 " 1/32	4 13/16	2 5/8	11/16	5 " 1/64
6	10	11 1/2 " 3/64	5 1/4	2 1/2	3/4	5 7/16 " 3/64

WEIGHT OF BOLTS AND NUTS PER PIECE.

Size.	3/8″	1/2″	5/8″	3/4″	7/8″	1″	1 1/8″	1 1/4″	1 3/8″	1 1/2″	1 5/8″	1 3/4″	1 7/8″	2″
	Lb.	Lb	Lb.	Lb.	Lb	Lb.	Lb.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Bolt Per Inch	.031	.054	.084	.122	.167	.218	.276	.335	.412	.491	.576	.668	.766	.872
Square Head	.045	.093	.167	.271	.412	.596	.806	1.110	1.455	1.860	2.370	2.880	3.530	4.210
Square Nut	.037	.080	.143	.250	.370	.554	.730	.990	1.350	1.590	2.080	2.700	3.225	3.840
Hexagon Head	.042	.076	.148	.235	.368	.513	.740	.971	1.255	1.600	2.010	2.590	3.190	3.735
Hexagon Nut	.031	.067	.118	.193	.294	.434	.606	.820	1.065	1.333	1.723	2.270	2.630	3.225
Countersunk Head . . .	.008	.014	.031	.047	.054	.083	.	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Button Head	.011	.042	.094	.171	.294	.448	. . .	. .	. . .	. . .	. . .	. .	. . .	. . .
Round Head	.040	.075	.125	.192	.310	.468	.614	.872	.968	1.384	1.790	2.165	2.636	3.200
Square Under Head (Extra)	.003	.007	.014	.026	.041	.060	. . .	. . .	. . .	. . .	. . .	. .	. . .	. . .

CAPACITIES OF TANKS PER FOOT

Width of Tank.	Length									
	2′	2′ 6″	3′	3′ 6″	4′	4′ 6″	5′	5′ 6″	6′	6′ 6″
	Gal	Gal.	Gal.	Gal.	Gal.	Gal.	Gal.	Gal.	Gal.	Gal.
2 ft.	29.9	37.4	44.88	52.36	59.84	67.32	74.8	82.28	89.76	97.24
2 ft. 6 in.	...	46.75	56.1	65.45	74.80	84.15	93.5	102.85	112.20	121.55
3 ft.	...	...	67.32	78.54	69.76	101	112 2	123.42	134.64	145.86
3 ft. 6 in.			...	91.63	104.72	117.81	130.9	144.	157.08	170.17
4 ft.		...	...	...	119.68	134.64	149.6	164.56	179.52	194.48
4 ft. 6 in.			...	...	...	151.47	168.30	185.13	202.	218.79
5 ft.	...	...	...	...	...	...	187	205.7	224 4	243.1
5 ft. 6 in.	...		...	...			...	226.27	246.84	267.41
6 ft.		...	...	...	...	...	...	...	269.28	291.72
6 ft. 6 in.	...		...	...	...	...	...	...	...	316.03
7 ft.	...	...	...	...	...	...	...	...	...	...
7 ft. 6 in.			...	...	...	...	...	...	...	...
8 ft.				...	...	...	...	...	...	...
8 ft. 6 in.				...	...	...	...	...	...	...
9 ft.	...				...	...	...	...	...	...
9 ft. 6 in.			...			...	...	...	...	...
10 ft.		...	...	...	...	...	...	...	...	...

NOTE.—To convert to British gallons, multiply by .83.

OF DEPTH (Rectangular).

OF TANK.										
7′	7′ 6″	8′	8′ 6″	9′	9′ 6″	10′	10′ 6″	11′	11′ 6″	13′
Gal. 104.72	Gal. 112.20	Gal. 119.68	Gal. 127.16	Gal. 134.64	Gal. 142.12	Gal. 149.6	Gal. 157.	Gal. 164.56	Gal. 172.	Gal. 179.52
130.9	140.25	149.6	158.95	168.3	177.65	187.	196.35	205.7	215.05	224.4
157.	168.3	179.52	190.74	202.	213.18	224.4	235.62	246.84	258.06	269.28
183.26	196.35	209.44	222.53	235.62	248.71	261.8	274.89	288.	301.07	314.16
209.44	224.4	239.36	254.32	269.28	299.2	314.16	329.12	344.08	359.	374.
235.62	252.45	269.28	286.11	303.	319.77	336.6	353.43	370.26	387.09	404.
261.8	280.5	299.2	317.9	336.6	355.3	374.	392.7	411.4	430.1	448.8
288.	308.55	329.12	349.7	370.26	390.83	411.4	332.	452.54	473.11	493.68
314.16	336.6	359.04	381.48	403.92	426.36	448.80	471.24	493.68	516.12	538.56
340.34	364.65	388.96	413.27	437.58	461.89	486.2	510.51	534.82	559.13	583.44
366.52	392.70	418.88	445.06	471.24	497.42	523.6	549.78	575.96	602.14	628.32
. . .	420.75	448.8	476.85	405.9	532.95	561.	589.05	617.1	645.15	673.2
. . .	. . .	478.72	508.64	538.56	568.48	598.4	628.32	658.24	688.16	718.08
. . .	. . .	. . .	540.43	572.22	604.01	635.80	667.59	699.38	731.17	762.96
. . .	. . .	. . .	. . .	605.88	639.54	673.2	706.86	740.52	774.18	807.84
. . .	. . .	. . .	. .	. . .	675.07	710.6	746.13	781.66	817.19	852.72
. . .	. . .	. . .	. . .	. . .	. . .	748.	785.4	822.8	860.2	897.6

Weight of a U.S. gallon = $8\frac{1}{3}$ lbs. Weight of a British gallon, F.W. = 10 lbs.

CONTENTS OF TANKS PER FOOT OF DEPTH (Cylindrical).

Diam. Ft.	Diam. In.	U.S. Gallons. 1 Foot in Depth.	Diam. Ft.	Diam. In.	U.S. Gallons. 1 Foot in Depth.	Diam. Ft.	Diam. In.	U.S. Gallons. 1 Foot in Depth.
1	0	5.87	11	0	710.69	21	0	2,590.22
1	3	9.17	11	3	743.36	21	3	2,652.25
1	6	13.21	11	6	776.77	21	6	2,715.04
1	9	17.98	11	9	810.91	21	9	2,778.54
2	0	23.49	12	0	848.18	22	0	2,842.79
2	3	29.73	12	3	881.39	22	3	2,907.76
2	6	36.70	12	6	917.73	22	6	2,973.48
2	9	44.41	12	9	954.81	22	9	3,039.92
3	0	52.86	13	0	992.62	23	0	3,107.10
3	3	62.03	13	3	1,031.17	23	3	3,175.01
3	6	73.15	13	6	1,070.45	23	6	3,243.65
3	9	82.59	13	9	1,108.06	23	9	3,313.04
4	0	93.97	14	0	1,151.21	24	0	3,383.15
4	3	103.03	14	3	1,192.69	24	3	3,454.00
4	6	118.93	14	6	1,234.91	24	6	3,525.59
4	9	132.52	14	9	1,277.86	24	9	3,597.90
5	0	146.83	15	0	1,321.54	25	0	3,670.95
5	3	161.88	15	3	1,365.96	25	3	3,744.74
5	6	117.67	15	6	1,407.51	25	6	3,819.26
5	9	194.19	15	9	1,457.00	25	9	3,894.52
6	0	211.44	16	0	1,503.62	26	0	3,970.50
6	3	229.43	16	3	1,550.97	26	3	4,047.23
6	6	248.15	16	6	1,599.06	26	6	4,124.68
6	9	267.61	16	9	1,647.89	26	9	4,202.96
7	0	287.80	17	0	1,697.45	27	0	4,281.80
7	3	308.72	17	3	1,747.74	27	3	4,361.46
7	6	330.38	17	6	1,798.76	27	6	4,441.86
7	9	352.76	17	9	1,850.53	27	9	4,522.98
8	0	375.90	18	0	1,903.02	28	0	4,604.85
8	3	399.76	18	3	1,956.25	28	3	4,686.48
8	6	424.36	18	6	2,010.21	28	6	4,770.77
8	9	449.21	18	9	2,064.91	28	9	4,854.84
9	0	475.75	19	0	2,120.34	29	0	4,939.64
9	3	502.55	19	3	2,176.51	29	3	5,025.17
9	6	530.08	19	6	2,233.29	29	6	5,111.44
9	9	558.35	19	9	2,291.04	29	9	5,198.44
10	0	587.35	20	0	2,349.41	30	0	5,286.18
10	3	617.08	20	3	2,408.51	30	3	5,374.65
10	6	647.55	20	6	2,468.35	30	6	5,463.85
10	9	678.27	20	9	2,528.92	30	9	5,553.79

NOTE. — To convert to British gallons, × .83.

PRESSURE OF WATER AT VARIOUS HEADS.

Formula: $P = H' \times .4334 =$ Pounds.
$P = H' \times .0304 =$ Kilos.

Depth of Water, *H*.	Pressure, *P*, in Pounds per Sq. In.	Pressure, *P*, in Kilos per Sq. Cm.	Depth of Water, *H*.	Pressure, *P*, in Pounds per Sq. In.	Pressure, *P*, in Kilos per Sq. Cm.	Depth of Water, *H*.	Pressure, *P*, in Pounds per Sq. In.	Pressure, *P*, in Kilos per Sq. Cm.
1 in.	.03608	.002537	27 ft.	11.691	.82196	64 ft.	27.712	1.94836
2	.07216	.005074	28	12.124	.85240	65	28.145	1.97880
3	.10824	.007611	29	12.557	.88284	66	28.578	2.00925
4	.14432	.010148	30	12.990	.91329	67	29.011	2.03969
5	.18040	.012685	31	13.423	.94373	68	29.444	2.07013
6	.21648	.015222	32	13.856	.97417	69	29.877	2.10057
7	.25256	.017759	33	14.289	1.00462	70	30.310	2.13102
8	.28864	.020296	34	14.722	1.03406	71	30.743	2.16146
9	.32472	.022833	35	15.155	1.06450	72	31.176	2.19190
10	.36080	.025370	36	15.588	1.09495	73	31.609	2.22235
11	.39688	.027907	37	16.021	1.12539	74	32.042	2.25279
1 ft.	.433	.030443	38	16.454	1.15583	75	32.475	2.28323
2	.866	.060886	39	16.887	1.18627	76	32.908	2.31368
3	1.299	.091329	40	17.320	1.21773	77	33.341	2.34412
4	1.732	.121773	41	17.753	1.24817	78	33.774	2.37456
5	2.165	.152216	42	18.186	1.27861	79	34.207	2.40500
6	2.598	.182659	43	18.619	1.30906	80	34.640	2.43545
7	3.031	.213102	44	19.052	1.33950	81	35.073	2.46589
8	3.464	.243545	45	19.485	1.36994	82	35.506	2.49633
9	3.897	.273989	46	19.918	1.40039	83	35.939	2.52678
10	4.330	.30443	47	20.351	1.43083	84	36.372	2.55722
11	4.763	.33487	48	20.784	1.46127	85	36.805	2.58766
12	5.196	.36531	49	21.217	1.49171	86	37.238	2.61811
13	5.629	.39576	50	21.650	1.52216	87	37.671	2.64855
14	6.062	.42620	51	22.083	1.55260	88	38.104	2.67899
15	6.495	.45664	52	22.516	1.58304	89	38.537	2.70943
16	6.928	.48709	53	22.949	1.61349	90	38.970	2.73989
17	7.361	.51753	54	23.382	1.64393	91	39.403	2.77033
18	7.794	.54797	55	23.815	1.67437	92	39.836	2.80077
19	8.227	.57841	56	24.248	1.70482	93	40.269	2.83122
20	8.660	.60886	57	24.681	1.73526	94	40.702	2.86166
21	9.093	.63930	58	25.114	1.76570	95	41.135	2.89210
22	9.526	.66974	59	25.557	1.79614	96	41.568	2.92255
23	9.959	.70019	60	25.980	1.82659	97	42.001	2.95299
24	10.392	.73063	61	26.413	1.85703	98	42.434	2.98343
25	10.825	.76107	62	26.846	1.88747	99	42.867	3.01387
26	11.258	.79152	63	27.279	1.91792	100	43.300	3.04432

The above table is calculated for fresh water at a temperature of 62° F.

UNIT EQUIVALENTS.

HEAT, ELECTRICAL AND MECHANICAL.

Unit.	Equivalents.
1 K.W. hour=	1,000 watt hours. 1.34 horse-power hours. 2,654,200 ft.-lbs. 3,600,000 joules. 3,412 heat units. 367,000 kilogram metres. 0.235 lb. carbon oxidized with perfect efficiency. 3.53 lbs. water evaporated from and at 212 degrees F. 22.75 lbs. of water raised from 62 degrees to 212 degrees F.
1 H.P. hour=	0.746 K.W. hour. 1,980,000 ft.-lbs. 2,545 heat-units. 273,740 k.g.m. 0.175 lb. carbon oxidized with perfect efficiency. 2.64 lbs. water evaporated from and at 212 degrees F. 17.0 lbs. water raised from 62 degrees to 212 degrees F.
1 kilowatt=	1,000 watts. 1.34 horse-power. 2,654,200 ft.-lbs. per hour. 44,240 ft.-lbs. per minute. 737.3 ft.-lbs. per second. 3,412 heat-units per hour. 56.9 heat-units per minute. 0.948 heat-unit per second. 0.2275 lb. carbon oxidized per hour. 3.53 lbs. water evaporated per hour from and at 212 degrees F.
1 H.P.=	746 watts. 0.746 K.W. 33,000 ft.-lbs. per minute. 550 ft.-lbs. per second. 2,455 heat-units per hour. 42.4 heat-units per minute. 0.707 heat-unit per second. 0.175 lb. carbon oxidized per hour. 2.64 lbs. water evaporated per hour from and at 212 degrees F.

UNIT EQUIVALENTS. — (*Continued.*)

HEAT, ELECTRICAL AND MECHANICAL.

UNIT.	EQUIVALENTS.
1 Joule=	1 watt second. 0.000000278 K.W. hour. 0.102 k.g.m. 0.0009477 heat-unit. 0.7373 ft.-lbs.
1 ft.-lb.=	1.356 joules. 0.1383 k.g.m. 0.000000377 K.W. hour. 0.001285 heat-unit. 0.0000005 H.P. hour.
1 watt=	1 joule per second. 0.00134 H.P. 3.412 heat-units per hour. 0.7373 ft.-lb. per second. 0.0035 lb. water evaporated per hour. 44.24 ft.-lbs. per minute.
1 watt per sq. in.=	8.19 heat-units per square foot per minute. 6371 ft.-lbs. per square foot per minute. 0.193 H.P. per square foot.
1 heat unit =	1,055 watt seconds. 778 ft.-lbs. 107.6 kilogram metres. 0.000293 K.W. hour. 0.000393 H.P. hour. 0.0000688 lb. carbon oxidized. 0.001036 lb. water evaporated from and at 212 degrees F.
1 heat unit per sq. ft. per min.=	0.122 watt per square inch. 0.0176 K.W. per square foot. 0.0236 H.P. per square foot.
1 kilogram metre=	7.233 ft.-lbs. 0.00000365 H.P. hour. 0.00000272 K.W. hour. 0.0093 heat-unit.

UNIT EQUIVALENTS.—(*Continued.*)

HEAT, ELECTRICAL AND MECHANICAL.

Unit.	Equivalents.
1 lb. carbon oxidized with perfect efficiency=	14,544 heat-units. 1.11 lbs. anthracite coal oxidised. 2.5 lbs. dry wood oxidised. 21 cubic feet illuminating-gas. 4.26 K.W. hours. 5.71 H.P. hours. 11,315,000 ft.-lbs. 15 lbs. of water evaporated from and at 212 degrees F.
1 lb. water evaporated from and at 212 degs. F.	0.283 K.W. hour. 0.379 H.P. hour. 965.7 heat-units. 103,900 k.g.m. 1,019,000 joules. 51,300 ft.-lbs. 0.0664 lb. of carbon oxidized.

WATER NOTES.

1 United States gallon	= 231 cubic inches.
1 United States gallon	= .83 British gallon.
1 United States gallon	= 3.8 litres.
1 United States gallon	= 8¼ pounds fresh water.
1 British gallon	= 277.274 cubic inches.
1 British gallon	= 1.205 United States gallons.
1 British gallon	= 4.543 litres.
1 British gallon	= 10 pounds fresh water.
1 cubic foot of sea water	= 64.05 pounds = .0286 ton.
1 cubic inch of sea water	= .037,035 pounds.
1 cubic foot of fresh water	= 62.39 pounds — .0279 ton.
1 cubic inch of fresh water	= .0361 pound.
1 ton of sea water	= 34.973 cubic feet.
1 ton of fresh water	= 35.905 cubic feet.
Weight of fresh water	= weight of salt water × .974.
1 cubic foot of fresh water	= 7.476 United States gallons.
1 cubic foot of fresh water	= 6.232 British gallons.
1 cubic foot of fresh water	= 28.375 litres.
1 litre of fresh water	= .264 United States gallon.
1 litre of fresh water	= .22 British gallon.
1 litre of fresh water	= 61.0 cubic inches.
1 litre of fresh water	= .0353 cubic foot.
Head of water in feet × .4334	= Pressure in lbs. per sq. in.
Head of water in feet × .0304	= Pressure in kilos per sq. cm.

AREAS OF CIRCLES.

Diameter.	Area.	Circumference.	Diameter.	Area.	Circumference.
1/32	.000767	.09817	17/32	.22166	1.6690
1/16	.003068	.19635	9/16	.24850	1.7671
3/32	.006903	.29452	19/32	.27688	1.8653
1/8	.012272	.39270	5/8	.30680	1.9635
5/32	.019175	.49087	21/32	.33824	2.0617
3/16	.027612	.58905	11/16	.37122	2.1598
7/32	.037583	.68722	23/32	.40574	2.2580
1/4	.049087	.78540	3/4	.44179	2.3562
9/32	.062126	.88357	25/32	.47937	2.4544
5/16	.076699	.98175	13/16	.51849	2.5525
11/32	.092806	1.0799	27/32	.55914	2.6507
3/8	.11045	1.1781	7/8	.60132	2.7489
13/32	.12962	1.2763	29/32	.64504	2.8471
7/16	.15033	1.3744	15/16	.69029	2.9452
15/32	.17257	1.4726	31/32	.73708	3.0434
1/2	.19635	1.5708	1	.78540	3.1416

AREAS OF CIRCLES

And Lengths of the Sides of Squares of the Same Area.

Diam. × .8862 = Side of Square.

Diam. of Circle in Ins.	Area of Circle in Sq. Ins.	Sides of Sq. of Same Area in Sq. Ins.	Diam. of Circle in Ins.	Area of Circle in Sq. Ins.	Sides of Sq. of Same Area in Sq. Ins.	Diam. of Circle in Ins.	Area of Circle in Sq. Ins.	Sides of Sq. of Same Area in Sq. Ins.
1	.785	.89	21	346.36	18.61	41	1,320.26	36.34
1½	1.767	1.33	21½	363.05	19.06	41½	1,352.66	36.78
2	3.142	1.77	22	380.13	19.50	42	1,385.45	37.22
2½	4.909	2.22	22½	397.61	19.94	42½	1,418.63	37.66
3	7.069	2.66	23	415.48	20.38	43	1,452.20	38.11
3½	9.621	3.10	23½	433.74	20.83	43½	1,486.17	38.55
4	12.566	3.54	24	452.39	21.27	44	1,520.53	[illegible]
4½	15.904	3.99	24½	471.44	21.71	44½	1,555.29	39.44
5	19.635	4.43	25	490.88	22.16	45	1,590.43	39.88
5½	23.758	4.87	25½	510.71	22.60	45½	1,625.97	40.32
6	28.274	5.32	26	530.93	23.04	46	1,661.91	40.77
6½	33.183	5.76	26½	551.55	23.49	46½	1,698.23	41.21
7	38.485	6.20	27	572.56	23.93	47	1,734.95	41.65
7½	44.179	6.65	27½	593.96	24.37	47½	1,772.06	42.10
8	50.266	7.09	28	615.75	24.81	48	1,809.56	42.56
8½	56.745	7.53	28½	637.94	25.26	48½	1,847.46	42.98
9	63.617	7.98	29	660.52	25.70	49	1,885.75	43.43
9½	70.882	8.42	29½	683.49	26.14	49½	1,924.43	43.87
10	78.540	8.86	30	706.86	26.59	50	1,963.50	44.31
10½	86.590	9.30	30½	730.62	27.03	50½	2,002.97	44.75
11	95.03	9.75	31	754.77	27.47	51	2,042.83	45.20
11½	103.87	10.19	31½	779.31	27.92	51½	2,083.08	45.64
12	113.10	10.63	32	804.25	28.36	52	2,123.72	46.08
12½	122.72	11.08	32½	829.58	28.80	52½	2,164.76	46.53
13	132.73	11.52	33	855.30	29.25	53	2,206.19	46.97
13½	143.14	11.96	33½	881.4[illegible]	29.69	53½	2,248.01	47.41
14	153.94	12.41	34	907.92	30.13	54	2,290.23	47.86
14½	165.13	12.85	34½	934.82	30.57	54½	2,332.83	48.30
15	176.72	13.29	35	962.11	31.02	55	2,375.83	48.74
15½	188.69	13.74	35½	989.80	31.46	55½	2,419.23	49.19
16	201.06	14.18	36	1,017.88	31.90	56	2,463.01	49.63
16½	213.83	14.62	36½	1,046.35	32.35	56½	2,507.19	50.07
17	226.98	15.07	37	1,075.21	32.79	57	2,551.76	50.51
17½	240.53	15.51	37½	1,104.47	33.23	57½	2,596.73	50.96
18	254.47	15.95	38	1,134.12	33.68	58	2,642.09	51.40
18½	268.80	16.40	38½	1,164.16	34.12	58½	2,687.84	51.84
19	283.53	16.84	39	1,194.59	34.56	59	2,733.98	52.29
19½	298.05	17.28	39½	1,225.42	35.01	59½	2,780.51	52.73
20	314.16	17.72	40	1,256.64	35.45	60	2,827.74	53.17
20½	330.06	18.17	40½	1,288.25	35.89	60½	2,874.76	53.62

SQUARES, CUBES, AND FOURTH POWERS OF FRACTIONS.

No.	Square.	Cube.	Fourth Power.	No.	Square.	Cube.	Fourth Power.
1/64	0.0002441	0.000003815	0.00000005961	41/64	0.4104	0.2629	0.1684
1/32	0.0009766	0.00003052	0.0000009537	21/32	0.4307	0.2826	0.1855
3/64	0.002197	0.0001030	0.000001922	43/64	0.4514	0.3033	0.2038
1/16	0.003906	0.0002441	0.00001526	11/16	0.4727	0.3250	0.2234
5/64	0.006104	0.0004768	0.00003725	45/64	0.4944	0.3476	0.2444
3/32	0.008789	0.0008240	0.00007725	23/32	0.5166	0.3713	0.2669
7/64	0.01196	0.001308	0.0001431	47/64	0.5393	0.3961	0.2909
1/8	0.01563	0.001953	0.0002441	3/4	0.5625	0.4219	0.3164
9/64	0.01978	0.002781	0.0003911	49/64	0.5862	0.4488	0.3436
5/32	0.02441	0.003815	0.0005961	25/32	0.6104	0.4768	0.3725
11/64	0.02954	0.005077	0.0008727	51/64	0.6350	0.5060	0.4032
3/16	0.03516	0.006592	0.001236	13/16	0.6602	0.5364	0.4358
13/64	0.04126	0.008381	0.001702	53/64	0.6858	0.5679	0.4703
7/32	0.04785	0.01047	0.002290	27/32	0.7119	0.6007	0.5068
15/64	0.05493	0.01287	0.003018	55/64	0.7385	0.6347	0.5454
1/4	0.06250	0.01563	0.003906	7/8	0.7656	0.6699	0.5862
17/64	0.07056	0.01874	0.004978	57/64	0.7932	0.7065	0.6290
9/32	0.07910	0.02225	0.006257	29/32	0.8213	0.7443	0.6745
19/64	0.08813	0.02617	0.007768	59/64	0.8499	0.7835	0.7223
5/16	0.09766	0.03052	0.009537	15/16	0.8789	0.8240	0.7725
21/64	0.1077	0.03533	0.01159	61/64	0.9084	0.8659	0.8253
11/32	0.1182	0.04062	0.01396	31/32	0.9385	0.9091	0.8807
23/64	0.1292	0.04641	0.01668	63/64	0.9690	0.9539	0.9390
3/8	0.1406	0.05273	0.01978	1	1.000	1.000	1.000
25/64	0.1526	0.05960	0.02328	1 1/64	1.031	1.048	1.064
13/32	0.1650	0.06705	0.02724	1 1/32	1.063	1.097	1.131
27/64	0.1780	0.07508	0.03168	1 3/64	1.096	1.147	1.201
7/16	0.1914	0.08374	0.03664	1 1/16	1.129	1.199	1.274
29/64	0.2053	0.09304	0.04216	1 5/64	1.162	1.253	1.351
15/32	0.2197	0.1030	0.04828	1 3/32	1.196	1.308	1.431
31/64	0.2346	0.1136	0.05505	1 7/64	1.231	1.365	1.515
1/2	0.2500	0.1250	0.06250	1 1/8	1.266	1.424	1.602
33/64	0.2659	0.1371	0.07069	1 9/64	1.301	1.484	1.693
17/32	0.2822	0.1499	0.07965	1 5/32	1.337	1.546	1.787
35/64	0.2991	0.1636	0.08944	1 11/64	1.373	1.609	1.996
9/16	0.3164	0.1780	0.1001	1 3/16	1.410	1.675	1.989
37/64	0.3342	0.1932	0.1117	1 13/64	1.448	1.742	2.095
19/32	0.3526	0.2093	0.1243	1 7/32	1.485	1.810	2.206
39/64	0.3713	0.2263	0.1379	1 15/64	1.524	1.881	2.322
5/8	0.3906	0.2441	0.1526	1 1/4	1.563	1.953	2.441

SQUARES, CUBES, AND FOURTH POWERS OF FRACTIONS.— (*Continued.*)

No.	Square.	Cube.	Fourth Power.	No.	Square.	Cube.	Fourth Power.
$1\frac{17}{64}$	1.602	2.027	2.566	$1\frac{41}{64}$	2.692	4.416	7.245
$1\frac{9}{32}$	1.642	2.103	2.695	$1\frac{21}{32}$	2.743	4.543	7.525
$1\frac{19}{64}$	1.682	2.181	2.829	$1\frac{43}{64}$	2.795	4.673	7.813
$1\frac{5}{16}$	1.723	2.261	2.968	$1\frac{11}{16}$	[redacted]	4.805	8.109
$1\frac{21}{64}$	1.764	2.343	3.111	$1\frac{45}{64}$	2.901	4.940	8.414
$1\frac{11}{32}$	1.806	2.426	3.260	$1\frac{23}{32}$	2.954	5.077	8.727
$1\frac{23}{64}$	1.848	2.512	3.415	$1\frac{47}{64}$	[redacted]	5.217	9.048
$1\frac{3}{8}$	1.891	2.600	3.575	$1\frac{3}{4}$	3.063	5.359	9.379
$1\frac{25}{64}$	1.934	2.689	3.740	$1\frac{49}{64}$	3.117	5.504	9.718
$1\frac{13}{32}$	1.978	2.781	3.911	$1\frac{25}{32}$	3.173	5.652	10.07
$1\frac{27}{64}$	2.022	2.875	4.087	$1\frac{51}{64}$	[redacted]	5.802	10.43
$1\frac{7}{16}$	2.066	2.970	4.270	$1\frac{13}{16}$	3.285	5.954	10.79
$1\frac{29}{64}$	2.112	3.068	4.459	$1\frac{53}{64}$	3.342	6.110	11.17
$1\frac{15}{32}$	2.157	3.168	4.654	$1\frac{27}{32}$	[redacted]	[redacted]	11.56
$1\frac{31}{64}$	2.203	3.271	4.855	$1\frac{55}{64}$	3.457	[redacted]	11.95
$1\frac{1}{2}$	2.250	3.375	5.063	$1\frac{7}{8}$	3.516	6.592	12.36
$1\frac{33}{64}$	2.297	3.482	5.277	$1\frac{57}{64}$	3.574	6.758	12.78
$1\frac{17}{32}$	2.345	3.590	5.498	$1\frac{29}{32}$	3.634	6.927	13.20
$1\frac{35}{64}$	2.393	3.701	5.726	$1\frac{59}{64}$	3.694	7.099	13.64
$1\frac{9}{16}$	2.441	3.815	5.961	$1\frac{15}{16}$	3.754	7.273	14.09
$1\frac{37}{64}$	2.490	3.930	6.203	$1\frac{61}{64}$	3.815	7.451	14.55
$1\frac{19}{32}$	2.540	4.048	6.452	$1\frac{31}{32}$	3.876	7.631	15.02
$1\frac{39}{64}$	2.590	4.168	6.709	$1\frac{63}{64}$	3.938	7.814	15.51
$1\frac{5}{8}$	2.641	4.291	6.973	2	4.000	8.000	16.00

POWERS AND ROOTS OF USEFUL FACTORS.

n	$\frac{1}{n}$	n^2	n^3	$\sqrt{n}$	$\frac{1}{\sqrt{n}}$	$\sqrt[3]{n}$	$\frac{1}{\sqrt[3]{n}}$
$\pi =$ 3.142	0.318	9.870	31.006	1.772	0.564	1.465	0.683
$2\pi =$ 6.283	0.159	39.478	248.050	2.507	0.399	1.845	0.542
$\pi/2 =$ 1.571	0.637	2.467	3.878	1.253	0.798	1.162	0.860
$\pi/3 =$ 1.047	0.955	1.097	1.148	1.023	0.977	1.016	0.985
$4/3\pi =$ 4.189	0.239	17.546	73.496	2.047	0.489	1.612	0.622
$\pi/4 =$ 0.785	1.274	0.617	0.484	0.886	1.128	0.923	1.084
$\pi/6 =$ 0.524	1.910	0.274	0.144	0.724	1.382	0.806	1.241
$\pi^2 =$ 9.870	0.101	97.409	961.390	3.142	0.318	2.145	0.466
$\pi^3 =$ 31.006	0.032	961.390	29,809.910	5.568	1.796	3.142	0.318
$\pi/32$ 0.098	10.186	0.0096	0.001	0.313	3.192	0.461	2.168
$g =$ 32.2	0.031	1036.84	33,386.24	5.674	0.176	3.181	0.314
$2g =$ 64.4	0.015	4147.36	267,000	8.025	0.125	4.007	0.249

SPEED TABLES.

(Based on the Admiralty Knot of 6,080 Feet.)*

1 Knot in = Min. Sec.	Admiralty Knots Per Hr.	1 Knot in = Min. Sec.	Admiralty Knots Per Hr.	1 Knot in = Min. Sec.	Admiralty Knots Per Hr.	1 Knot in = Min. Sec.	Admiralty Knots Per Hr.
1 30	40.000	1 38	36.734	1 46	33.962	1 54	31.578
1 30.2	39.911	1 38.2	36.659	1 46.2	33.898	1 54.2	31.523
1 30.4	39.823	1 38.4	36.585	1 46.4	33.834	1 54.4	31.468
1 30.6	39.735	1 38.6	36.511	1 46.6	33.771	1 54.6	31.413
1 30.8	39.647	1 38.8	36.437	1 46.8	33.707	1 54.8	31.358
1 31	39.560	1 39	36.363	1 47	33.644	1 55	31.304
1 31.2	39.473	1 39.2	36.290	1 47.2	33.581	1 55.2	31.250
1 31.4	39.387	1 39.4	36.217	1 47.4	33.519	1 55.4	31.195
1 31.6	39.301	1 39.6	36.144	1 47.6	33.457	1 55.6	31.141
1 31.8	39.215	1 39.8	36.072	1 47.8	33.395	1 55.8	31.088
1 32	39.130	1 40	36.000	1 48	33.333	1 56	31.034
1 32.2	39.045	1 40.2	35.928	1 48.2	33.271	1 56.2	30.981
1 32.4	38.961	1 40.4	35.856	1 48.4	33.210	1 56.4	30.927
1 32.6	38.876	1 40.6	35.785	1 48.6	33.149	1 56.6	30.874
1 32.8	38.793	1 40.8	35.714	1 48.8	33.088	1 56.8	30.821
1 33	38.710	1 41	35.643	1 49	33.027	1 57	30.768
1 33.2	38.626	1 41.2	35.573	1 49.2	32.966	1 57.2	30.716
1 33.4	38.543	1 41.4	35.503	1 49.4	32.906	1 57.4	30.664
1 33.6	38.461	1 41.6	35.433	1 49.6	32.846	1 57.6	30.612
1 33.8	38.379	1 41.8	35.363	1 49.8	32.786	1 57.8	30.560
1 34	38.300	1 42	35.294	1 50	32.727	1 58	30.508
1 34.2	38.216	1 42.2	35.225	1 50.2	32.668	1 58.2	30.456
1 34.4	38.135	1 42.4	35.156	1 50.4	32.608	1 58.4	30.405
1 34.6	38.054	1 42.6	35.087	1 50.6	32.549	1 58.6	30.354
1 34.8	37.974	1 42.8	35.019	1 50.8	32.490	1 58.8	30.303
1 35	37.894	1 43	34.951	1 51	32.432	1 59	30.252
1 35.2	37.815	1 43.2	34.883	1 51.2	32.365	1 59.2	30.201
1 35.4	37.736	1 43.4	34.816	1 51.4	32.315	1 59.4	30.150
1 35.6	37.657	1 43.6	34.749	1 51.6	32.258	1 59.6	30.100
1 35.8	37.578	1 43.8	34.682	1 51.8	32.200	1 59.8	30.050
1 36	37.500	1 44	34.614	1 52	32.142	2 0	30.000
1 36.2	37.422	1 44.2	34.548	1 52.2	32.085	2 0.2	29.950
1 36.4	37.344	1 44.4	34.482	1 52.4	32.028	2 0.4	29.900
1 36.6	37.267	1 44.6	34.416	1 52.6	31.971	2 0.6	29.850
1 36.8	37.190	1 44.8	34.351	1 52.8	31.914	2 0.8	29.801
1 37	37.113	1 45	34.285	1 53	31.858	2 1	29.752
1 37.2	37.037	1 45.2	34.220	1 53.2	31.802	2 1.2	29.702
1 37.4	36.961	1 45.4	34.155	1 53.4	31.746	2 1.4	29.654
1 37.6	36.885	1 45.6	34.090	1 53.6	31.690	2 1.6	29.605
1 37.8	36.809	1 45.8	34.026	1 53.8	31.634	2 1.8	29.556

* The knot, or nautical mile, is actually 6,082.66 feet.
The statute, or land, mile is 5,280 feet.

SPEED TABLES.— (*Continued.*)

1 Knot in = Min.	Sec.	Admiralty Knots Per Hr.	1 Knot in = Min.	Sec.	Admiralty Knots Per Hr.	1 Knot in = Min.	Sec.	Admiralty Knots Per Hr.	1 Knot in = Min.	Sec.	Admiralty Knots Per Hr.
2	2	29.508	2	11	27.480	2	20	25.714	2	29	24.161
2	2.2	29.459	2	11.2	27.438	2	20.2	25.677	2	29.2	24.128
2	2.4	29.411	2	11.4	27.396	2	20.4	25.641	2	29.4	24.096
2	2.6	29.363	2	11.6	27.355	2	20.6	25.604	2	29.6	24.064
2	2.8	29.315	2	11.8	27.314	2	20.8	25.568	2	29.8	24.032
2	3	29.268	2	12	27.272	2	21	25.532	2	30	24.000
2	3.2	29.220	2	12.2	27.231	2	21.2	25.495	2	30.2	23.968
2	3.4	29.173	2	12.4	27.190	2	21.4	25.459	2	30.4	23.936
2	3.6	29.126	2	12.6	27.149	2	21.6	25.423	2	30.6	23.904
2	3.8	29.079	2	12.8	27.108	2	21.8	25.387	2	30.8	23.872
2	4	29.032	2	13	27.066	2	22	25.352	2	31	23.840
2	4.2	28.985	2	13.2	27.026	2	22.2	25.316	2	31.2	23.809
2	4.4	28.938	2	13.4	26.986	2	22.4	25.280	2	31.4	23.778
2	4.6	28.892	2	13.6	26.946	2	22.6	25.245	2	31.6	23.746
2	4.8	28.846	2	13.8	26.905	2	22.8	25.210	2	31.8	23.715
2	5	28.800	2	14	26.864	2	23	25.174	2	32	23.684
2	5.2	28.753	2	14.2	26.825	2	23.2	25.139	2	32.2	23.653
2	5.4	28.708	2	14.4	26.785	2	23.4	25.104	2	32.4	23.622
2	5.6	28.662	2	14.6	26.745	2	23.6	25.069	2	32.6	23.591
2	5.8	28.616	2	14.8	26.705	2	23.8	25.034	2	32.8	23.560
2	6	28.570	2	15	26.666	2	24	25.000	2	33	23.529
2	6.2	28.526	2	15.2	26.627	2	24.2	24.965	2	33.2	23.498
2	6.4	28.481	2	15.4	26.687	2	24.4	24.930	2	33.4	23.468
2	6.6	28.436	2	15.6	26.548	2	24.6	24.896	2	33.6	23.437
2	6.8	28.391	2	15.8	26.509	2	24.8	24.861	2	33.8	23.407
2	7	28.346	2	16	26.470	2	25	24.827	2	34	23.376
2	7.2	28.301	2	16.2	26.431	2	25.2	24.793	2	34.2	23.334
2	7.4	28.257	2	16.4	26.392	2	25.4	24.759	2	34.4	23.316
2	7.6	28.213	2	16.6	26.354	2	25.6	24.725	2	34.6	23.285
2	7.8	28.169	2	16.8	26.315	2	25.8	24.691	2	34.8	23.255
2	8	28.126	2	17	26.278	2	26	24.657	2	35	23.225
2	8.2	28.081	2	17.2	26.239	2	26.2	24.623	2	35.2	23.195
2	8.4	28.037	2	17.4	26.200	2	26.4	24.590	2	35.4	23.166
2	8.6	27.993	2	17.6	26.162	2	26.6	24.556	2	35.6	23.136
2	8.8	27.950	2	17.8	26.124	2	26.8	24.523	2	35.8	23.106
2	9	27.906	2	18	26.086	2	27	24.489	2	36	23.076
2	9.2	27.863	2	18.2	26.048	2	27.2	24.456	2	36.2	23.334
2	9.4	27.820	2	18.4	26.011	2	27.4	24.423	2	36.4	23.017
2	9.6	27.777	2	18.6	25.973	2	27.6	24.390	2	36.6	22.988
2	9.8	27.734	2	18.8	25.936	2	27.8	24.357	2	36.8	22.959
2	10	27.692	2	19	25.899	2	28	24.324	2	37	22.930
2	10.2	27.649	2	19.2	25.862	2	28.2	24.291	2	37.2	22.900
2	10.4	27.607	9	19.4	25.824	2	28.4	24.258	2	37.4	22.871
2	10.6	27.565	2	19.6	25.787	2	28.6	24 226	2	37.6	22.842
2	10.8	27.522	2	19.8	25.750	2	28.8	24.193	2	37.8	22.813

SPEED TABLES.—(*Continued.*)

1 Knot in = Min. Sec.	Admiralty Knots Per Hr.	1 Knot in = Min. Sec.	Admiralty Knots Per Hr.	1 Knot in = Min. Sec.	Admiralty Knots Per Hr.	1 Knot in = Min. Sec.	Admiralty Knots Per Hr.
2 38	22.784	2 47	21.556	2 56	20.454	3 25	17.560
2 38.2	22.756	2 47.2	21 531	2 56.2	20.431	3 26	17.475
2 38.4	22.727	2 47.4	21.505	2 56.4	20.408	3 27	17.391
2 38.6	22.698	2 47.6	21.479	2 56.6	20.385	3 28	17.307
2 38.8	22.670	2 47.8	21.454	2 56.8	20.361	3 29	17.225
2 39	22.646	2 48	21.428	2 57	20.338	3 30	17.142
2 39.2	22.613	2 48.2	21.403	2 57.2	20.316	3 31	17.061
2 39.4	22.584	2 48.4	21.377	2 57.4	20.293	3 32	16.981
2 39.6	22.556	2 48.6	21.352	2 57.6	20.270	3 33	16.901
2 39.8	22.528	2 48.8	21.327	2 57.8	20.247	3 34	16.822
2 40	22.500	2 49	21.302	2 58	20.224	3 35	16.744
2 40.2	22.471	2 49.2	21.276	2 58.2	20.202	3 36	16.667
2 40.4	22.443	2 49.4	21.251	2 58.4	20.179	3 37	16.590
2 40.6	22.415	2 49.6	21.226	2 58.6	20.156	3 38	16.514
2 40.8	22.388	2 49.8	21.201	2 58.8	20.134	3 39	16.438
2 41	22.360	2 50	21.176	2 59	20.111	3 40	16.363
2 41.2	22.332	2 50.2	21.151	2 59.2	20.089	3 41	16.289
2 41.4	22.304	2 50.4	21.126	2 59.4	20.066	3 42	16.216
2 41.6	22.277	2 50.6	21.101	2 59.6	20.044	3 43	16.143
2 41.8	22.249	2 50.8	21.077	2 59.8	20.022	3 44	16.071
2 42	22.222	2 51	21.052	3 0	20.000	3 45	16.000
2 42.2	22.194	2 51.2	21.028	3 1	19.890	3 46	15.929
2 42.4	22.167	2 51.4	21.003	3 2	19.780	3 47	15.859
2 42.6	22.140	2 51.6	20.978	3 3	19.672	3 48	15.789
2 42.8	22.113	2 51.8	20.954	3 4	19.564	3 49	15.721
2 43	22.086	2 52	20.930	3 5	19.460	3 50	15.652
2 43.2	22.058	2 52.2	20.905	3 6	19.355	3 51	15.584
2 43.4	22.031	2 52.4	20.881	3 7	19.251	3 52	15.517
2 43.6	22.004	2 52.6	20.857	3 8	19.150	3 53	15.450
2 43.8	21.978	2 52.8	20.833	3 9	19.047	3 54	15.384
2 44	21.951	2 53	20.808	3 10	18.947	3 55	15.319
2 44.2	21.924	2 53.2	20.784	3 11	18.848	3 56	15.254
2 44.4	21.897	2 53.4	20.761	3 12	18.750	3 57	15.190
2 44.6	21.871	2 53.6	20.737	3 13	18.652	3 58	15.126
2 44.8	21.844	2 53.8	20.713	3 14	18.556	3 59	15.062
2 45	21.818	2 54	20.689	3 15	18.461	4 00	15.000
2 45.2	21.791	2 54.2	20.665	3 16	18.367	4 1	14.938
2 45.4	21.765	2 54.4	20.642	3 17	18.274	4 2	14.876
2 45.6	21.739	2 54.6	20.618	3 18	18.181	4 3	14.815
2 45.8	21.712	2 54.8	20.594	3 19	18.090	4 4	14.754
2 46	21.686	2 55	20.571	3 20	18.000	4 5	14.694
2 46.2	21.660	2 55.2	20.547	3 21	17.910	4 6	14.634
2 46.4	21.634	2 55.4	20.524	3 22	17.823	4 7	14.575
2 46.6	21.608	2 55.6	20.501	3 23	17.734	4 8	14.516
2 46.8	21.582	2 55.8	20.477	3 24	17.647	4 9	14.457

SPEED TABLES.—(*Continued.*)

1 Knot in Min.	Sec.	= Admiralty Knots Per Hr.	1 Knot in Min.	Sec.	= Admiralty Knots Per Hr.	1 Knot in Min.	Sec.	= Admiralty Knots Per Hr.	1 Knot in Min.	Sec.	= Admiralty Knots Per Hr.
4	10	14.400	4	55	12.203	5	40	10.588	6	25	9.350
4	11	14.342	4	56	12.162	5	41	10.557	6	26	9.326
4	12	14.285	4	57	12.121	5	42	10.526	6	27	9.302
4	13	14.229	4	58	12.080	5	43	10.495	6	28	9.278
4	14	14.173	4	59	12.040	5	44	10.465	6	29	9.254
4	15	14.118	5	00	12.000	5	45	10.434	6	30	9.230
4	16	14.063	5	1	11.960	5	46	10.404	6	31	9.207
4	17	14.008	5	2	11.920	5	47	10.375	6	32	9.183
4	18	13.953	5	3	11.880	5	48	10.345	6	33	9.160
4	19	13.900	5	4	11.841	5	49	10.315	6	34	9.137
4	20	13.846	5	5	11.803	5	50	10.286	6	35	9.113
4	21	13.793	5	6	11.764	5	51	10.256	6	36	9.090
4	22	13.740	5	7	11.726	5	52	10.227	6	37	9.068
4	23	13.688	5	8	11.688	5	53	10.198	6	38	9.044
4	24	13.636	5	9	11.650	5	54	10.169	6	39	9.022
4	25	13.584	5	10	11.613	5	55	10.140	6	40	9.000
4	26	13.533	5	11	11.575	5	56	10.112	6	41	8.977
4	27	13.483	5	12	11.538	5	57	10.084	6	42	8.955
4	28	13.432	5	13	11.501	5	58	10.055	6	43	8.933
4	29	13.383	5	14	11.465	5	59	10.027	6	44	8.911
4	30	13.333	5	15	11.428	6	00	10.000	6	45	8.889
4	31	13.284	5	16	11.392	6	1	9.972	6	46	8.867
4	32	13.235	5	17	11.356	6	2	9.944	6	47	8.845
4	33	13.186	5	18	11.323	6	3	9.917	6	48	8.823
4	34	13.138	5	19	11.285	6	4	9.890	6	49	8.801
4	35	13.092	5	20	11.250	6	5	9.863	6	50	8.780
4	36	13.043	5	21	11.214	6	6	9.836	6	51	8.759
4	37	12.996	5	22	11.180	6	7	9.809	6	52	8.737
4	38	12.950	5	23	11.146	6	8	9.783	6	53	8.716
4	39	12.903	5	24	11.111	6	9	9.756	6	54	8.695
4	40	12.857	5	25	11.077	6	10	9.729	6	55	8.675
4	41	12.811	5	26	11.043	6	11	9.703	6	56	8.654
4	42	12.766	5	27	11.009	6	12	9.677	6	57	8.633
4	43	12.720	5	28	10.975	6	13	9.651	6	58	8.612
4	44	12.676	5	29	10.942	6	14	9.625	6	59	8.591
4	45	12.631	5	30	10.909	6	15	9.600	7	00	8.571
4	46	12.587	5	31	10.876	6	16	9.574	7	1	8.551
4	47	12.543	5	32	10.843	6	17	9.549	7	2	8.530
4	48	12.500	5	33	10.810	6	18	9.524	7	3	8.510
4	49	12.456	5	34	10.778	6	19	9.499	7	4	8.490
4	50	12.413	5	35	10.746	6	20	9.473	7	5	8.470
4	51	12.371	5	36	10.714	6	21	9.448	7	6	8.450
4	52	12.329	5	37	10.682	6	22	9.424	7	7	8.430
4	53	12.287	5	38	10.651	6	23	9.399	7	8	8.413
4	54	12.245	5	39	10.619	6	24	9.375	7	9	8.392

SPEED TABLES. — (*Concluded.*)

1 Knot in = Min. Sec.	Admiralty Knots Per Hr.	1 Knot in = Min. Sec.	Admiralty Knots Per Hr.	1 Knot in = Min. Sec.	Admiralty Knots Per Hr.	1 Knot in = Min. Sec.	Admiralty Knots Per Hr.
7 10	8.372	7 35	7.912	7 55	7.579	8 15	7.272
7 11	8.353	7 36	7.895	7 56	7.563	8 16	7.258
7 12	8.334	7 37	7.877	7 57	7.547	8 17	7.243
7 13	8.315	7 38	7.860	7 58	7.531	8 18	7.229
7 14	8.295	7 39	7.843	7 59	7.515	8 19	7.214
7 15	8.276	7 40	7.826	8 0	7.500	8 20	7.200
7 16	8.257	7 41	7.809	8 1	7.484	8 21	7.185
7 17	8.228	7 42	7.792	8 2	7.468	8 22	7.171
7 18	8.219	7 43	7.775	8 3	7.453	8 23	7.157
7 19	8.200	7 44	7.758	8 4	7.438	8 24	7.142
7 20	8.181	7 45	7.741	8 5	7.422	8 25	7.128
7 21	8.163	7 46	7.725	8 6	7.407	8 26	7.114
7 22	8.144	7 47	7.708	8 7	7.392	8 27	7.100
7 23	8.127	7 48	7.692	8 8	7.377	8 28	7.086
7 24	8.108	7 49	7.675	8 9	7.362	8 29	7.072
7 25	8.090	7 50	7.659	8 10	7.346	8 30	7.059
7 26	8.071	7 51	7.643	8 11	7.331	8 31	7.045
7 27	8.053	7 52	7.627	8 12	7.317	8 32	7.031
7 28	8.035	7 53	7.611	8 13	7.302	8 33	7.017
7 29	8.017	7 54	7.595	8 14	7.287	8 34	7.004
7 30	8.000	....	....	....	....	....	....
7 31	7.982	....	....	....	....	....	....
7 32	7.964	....	....	....	....	....	....
7 33	7.947	....	....	....	....	....	....
7 34	7.929	....	....	....	....	....	....

FOREIGN WEIGHTS AND MEASURES WITH EQUIVALENTS.

Denomination.	Where Used.	American Equivalent.
Almude	Portugal	4.422 gallons.
Ardeb	Egypt	7.6907 bushels.
Arobe	Paraguay	25 pounds.
Arratel or libra	Portugal	1.011 pounds.
Arroba (dry)	Argentina	25.3175 pounds.
"	Brazil	32.38 pounds.
"	Cuba	25.3664 pounds.
"	Portugal	32.38 pounds.
"	Spain	25.36 pounds.
"	Venezuela	25.4024 pounds.
Arroba (liquid)	Cuba, Spain, and Venezuela	4.263 gallons.
Arshine	Russia	28 inches.
Arshine (square)	"	5.44 square feet.
Artel	Morocco	1.12 pounds.
Barrel	Malta (customs)	11.4 gallons.
"	Spain (raisins)	100 pounds.
Barril	Argentina and Mexico	20.0787 gallons.
Berkovetz	Russia	361.12 pounds.
Bongkal	India	832 grains.
Bouw	Sumatra	7,096.5 square metres.
Bu	Japan	0.119 inch.
Butt	Spain (wine)	140 gallons.
Caffiso	Malta	5.4 gallons.
Candy	India (Bombay)	529 pounds.
"	India (Madras)	500 pounds.
Cantar	Egypt	99.5 pounds.
"	Morocco	113 pounds.
"	Syria (Damascus)	575 pounds.
"	Turkey	124.7036 pounds.
Cantaro (cantar)	Malta	175 pounds.
Carga	Colombia	250 pounds.
"	Mexico and Salvador	300 pounds.
Catty	China	1.333⅓ (1⅓) pounds.
"	Japan	1.32 pounds.
"	Java, Malacca, and Siam	1.35 pounds.
"	Sumatra	2.12 pounds.
Centaro	Central America	4.2631 gallons.

FOREIGN WEIGHTS AND MEASURES WITH EQUIVALENTS. — (*Continued.*)

Denomination.	Where Used.	American Equivalent.
Centner	Bremen and Brunswick	117.5 pounds.
"	Darmstadt	110.24 pounds.
"	Denmark and Norway	110.11 pounds.
"	Nuremberg	112.43 pounds.
"	Prussia	113.44 pounds.
"	Sweden	93.7 pounds.
"	Vienna	123.5 pounds.
"	Zollverein	110.24 pounds.
Chetvert	Russia	5.7748 bushels.
Chih	China	14 inches.
Coyan	Sarawak	3098 pounds.
"	Siam (Koyan)	2667 pounds.
Cuadra	Argentina	4.2 acres.
"	Paraguay	78.9 yards.
"	Paraguay (square)	8.077 square feet.
"	Uruguay	Nearly 2 acres.
Cwt. (hundredweight)	Great Britain	112 pounds.
Dessiatine	Russia	2.6997 acres.
"	Spain	1.599 bushels.
Drachme	Greece	1 gram.
Dun	Japan	1 inch.
Eutchek	Asia Minor (wheat)	10.61 pounds.
Fanega (dry)	Central America	1.5745 bushels.
"	Chile	2.575 bushels.
"	Cuba	1.599 bushels.
"	Mexico	1.54728 bushels.
"	Morocco	Strike fanega, 70 lbs., full fanega, 118 lbs.
"	Spain	1.6 bushels.
"	Uruguay (double)	7.776 bushels.
"	Uruguay (single)	3.888 bushels.
"	Venezuela	1.599 bushels.
Fanega (liquid)	Spain	16 gallons.
Feddan	Egypt	1.03 acres.
Frail	Spain (raisins)	50 pounds.
Frasco	Argentina	2.5096 quarts.
"	Mexico	2.5 quarts.
Frasila	Zanzibar	35 pounds.

FOREIGN WEIGHTS AND MEASURES WITH EQUIVALENTS. — (*Continued.*)

Denomination.	Where Used.	American Equivalent.
Fuder	Luzemburg	264.17 gallons.
Funt	Russia	0.9028 pound.
Garnice	Russian Poland	0.88 gallon.
Go	Japan	0.0000817 acre.
Joch	Austria-Hungary	1.422 acres.
Ken	Japan	5.965 feet.
Klafter	Russia	216 cubic feet.
Koku (dry)	Japan	5.118 bushels.
Koku (liquid)	"	47.653 gallons.
Korree	Russia	3.5 bushels.
Kota	Japan	5.13 bushels.
Kwan	"	8.27 pounds.
Last	Belgium and Holland	85.134 bushels.
"	England (dry malt)	82.52 bushels.
"	Germany	2 metric tons (4409.2 lbs.)
"	Prussia	112.29 bushels.
"	Russian Poland	$11\frac{1}{8}$ bushels.
"	Spain (salt)	4760 pounds.
League	Paraguay (land)	4633 acres.
Li	China	2115 feet.
Libra (pound)	Argentina	1.0127 pounds.
"	Castilian	7100 grains (troy).
"	Central America	1.043 pounds.
"	Chile	1.014 pounds.
"	Cuba	1.0161 pounds.
"	Mexico	1.01467 pounds.
Libra	Peru	1.0143 pounds.
"	Portugal	1.011 pounds.
"	Spain	1.0144 pounds.
"	Uruguay	1.0143 pounds.
"	Venezuela	1.0161 pounds.
Livre (pound)	Greece	1.1 pounds.
"	Guiana	1.0791 pounds.
Load	England (timber)	Square, 50 cubic feet; unhewn, 40 cubic feet; inch planks, 600 superficial feet.
Manzana	Costa Rica	$1\frac{5}{8}$ acres.
"	Nicaragua and Salvador	1.727 acres.

FOREIGN WEIGHTS AND MEASURES WITH EQUIVALENTS. — (*Continued.*)

Denomination.	Where Used.	American Equivalent.
Marc	Bolivia	0.507 pound.
Maund	India	82 2/7.
Mil	Denmark	4.68 miles.
"	Denmark (geographical)	4.61 miles.
Milla	Honduras and Nicaragua	1.1493 miles.
Morgen	Prussia	0.63 acre.
Oke	Egypt	2.7225 pounds.
"	Greece	2.75578 pounds.
"	Hungary	3.0817 pounds.
"	Hungary and Wallachia	2.5 pints.
"	Turkey	2.81857 pounds.
Pic	Egypt	21¼ inches.
Picul	Borneo and Celebes	135.64 pounds.
"	China, Japan, and Sumatra	133 pounds.
"	Java	135.1 pounds.
"	Philippine Islands (hemp)	139.45 pounds.
"	Philippine Islands (sugar)	140 pounds.
Pie	Argentina	0.9478 foot.
"	Spain	0.91407 foot.
Pik	Turkey	27.9 inches.
Pood	Russia	36.112 pounds.
Pund (pound)	Denmark and Sweden	1.102 pounds.
Quarter	Great Britain	8.252 bushels.
"	London (coal)	36 bushels.
Quintal	Argentina	101.42 pounds.
"	Brazil	130.06 pounds.
"	Castile, Chile, and Peru	101.41 pounds.
"	Greece	123.2 pounds.
"	Mexico	101.46 pounds.
"	Newfoundland (fish)	112 pounds.
"	Paraguay	100 pounds.
"	Syria	125 pounds.
Rottle	Palestine	6 pounds.
Rottle	Syria	5¾ pounds.
Sagene	Russia	7 feet.

FOREIGN WEIGHTS AND MEASURES WITH EQUIVALENTS. — (*Concluded.*)

Denomination.	Where Used.	American Equivalent.
Salm	Malta	490 pounds.
Se	Japan	0.02451 acre.
Seer	India	1 pound, 13 ounces.
Shaku	Japan	11.9303 inches.
Sho	Japan	1.6 dry quarts.
Standard	St. Petersburg (lumber measure)	165 cubic feet.
Stone	Great Britain	14 pounds.
Suerte	Uruguay	2700 cuadras (see cuadra).
Sun	Japan	1.193 inches.
Tael	Cochin China	590.75 grains (troy).
Tan	Japan	0.245 acre.
Tierce	Newfoundland	300 pounds.
To	Japan	2 pecks.
Tola	"	180 grains.
Tonde	Denmark (cereals)	3.94783 bushels.
Tondeland	Denmark	1.36 acres.
Tsubo	Japan	35.581 square feet.
Tsun	China	1.41 inches.
Tun	Newfoundland (cod oil)	306 gallons.
Tunna	Sweden	4.5 bushels.
Tunnland	"	1.22 acres.
Vara	Argentina	34.1208 inches.
"	Central America	32.87 inches.
"	Chile and Peru	33.367 inches.
"	Cuba	33.384 inches.
"	Curaçao	33.375 inches.
"	Mexico	32.992 inches.
"	Paraguay	34 inches.
"	Spain	0.99081 yard.
"	Venezuela	33.384 inches.
Vedro	Russia	2.707 gallons.
Venetian pound	Greece and Mediterranean countries	1.05 pounds.
Vergees	Isle of Jersey	71.1 square rods.
Verst	Russia	0.663 mile.
Vlocka	Russian Poland	41.98 acres.

STOWAGES OF MERCHANDISE.

	Cubic Feet per Ton.
Acid, sulphuric	24
Alcohol in casks	80
Almonds, shelled, in bags	70
Almonds in bales	108
Almonds in hogsheads	120
Aniseed in bags	120
Apparel	50
Apples in boxes	90
Arrowroot in boxes	70
Arrowroot in bags	52
Arrowroot in cases	50
Asbestos in cases	53
Ashes in casks	53
Ashes, some sorts	40–45
Asphalt	17
Bacon in cases	64–66
Bales, Manchester well pressed	48–50
Bales, canvas	42–45
Ballast, Thames shingle	22
Ballast, sand	19
Ballast, sand, coarse	20
Ballast, loose earth	24–25
Ballast, clay	17
Ballast, clay with gravel	18
Ballast (Thames)	22
Barley in bulk	47
Barley in bags	58–60
Beans, Haricot in bags	68
Beans in bulk	47
Beef (see Meat)	
Beer in bulk, hogsheads	54
Beer in bottles, in cases and casks	80
Beeswax	74
Beeswax in India	50
Blackwood	50
Bone meal	45
Bones, crushed	60
Bones, loose	85
Bones, calcined	106
Bone manure, common	72
Bone manure, best	53
Books	50
Borax in cases	50

STOWAGES OF MERCHANDISE — (*Continued.*)

	Cubic Feet per Ton.
Borax variable	42
Borate of lime	52
Bottles, empty, in crates	85
Bran in bags	110–104
Bran, compressed bales of	80
Brandy in casks	80
Brandy bottled, in cases	52–60
Bread in bulk	124
Bread in bags	140
Bread in casks	160
Bread in cases	156
Bricks (absorb about 15% moisture)	20
Bricks, wet	19
Bricks, 1000 new bricks about $3\frac{3}{4}$ tons, will stow in 75 cubic feet, 1000 old bricks, about 3 tons will stow in 68 to 70 cubic feet	
Buckwheat in bags	65
Bulbs in cases	80
Butter in cases or kegs	70
Camphor in cases	50
Candles in boxes	56
Canvas	47
Carpets in rolls	80
Carpets in bales	140
Casks, empty palm oil	400
Cassia in cases	184
Cassia in bundles	130
Cassia buds in cases	130
Cellulose	240
Cement, ordinary, in casks	46
Cement, Portland, in casks	35–37
Chalk in barrels	38
Charcoal (absorbs about 20% moisture)	40
Cheese	70
Chicory in sacks	60
Chloride of lime in casks	80
Cider in casks	65
Cigars in cases	180
Cinnamon in bales	50
Cinchona, Peruvian bark	130–150
Cloth goods in cases (uncertain)	85–90
Cloves in chests	50
Coal, Admiralty	48

STOWAGES OF MERCHANDISE. — (*Continued.*)

	Cubic Feet per Ton.
Coal, American	43
Coal, Newcastle	45
Coal, New River (Gas)	50
Coal, Welsh	40
Coal, Japan	43–45
Coal, Pocahontas	40
Cocoa in bags	80
Cocoanuts in bulk	140
Coffee in bags	61
Coffee in tierces	70
Coffee in parchment, in bags	80
Coir, yarn in bales	190
Coir, fibre	200
Coir, other kinds	200–220
Coke, heaped	80
Copper, manufactured	10
Copper ore	10–20
Copper sulphate in casks	50
Copperas, casks	52
Copra, desiccated, in cases, about	65
Copra in bales	85
Copra in cases	80–90
Cork, pressed bales	200
Cork, bales from France	440
Cork, wood, bales	270
Cork, shavings, in bales	290
Cotton, American, pressed (32 cubic feet per bale)	130
Cotton, American unpressed	200
Cotton, East Indian, bales	57–60
Cotton, good average, bales	52
Cotton, ordinarily pressed bales	67
Cotton, Egyptian, bales	58
Cotton, waste	170
Cowrie shells	40
Cowrie shells in bags	65–80
Creosote in casks	60
Currents in cases	50
Dates, wet	40
Dates, dry	45
Earth mould	33
Earthenware, jars in crates	47
Earthenware, retorts, loose	58

STOWAGES OF MERCHANDISE. — (*Continued.*)

	Cubic Feet per Ton.
Fish in cases	95
Fish, iced	60
Fish, oil, in cases	57
Fish manure	65
Firewood	288
Flax	88
Flax from Baltic ports	155
Flax from New York	108
Flour in barrels	60
Flour in bags	44–50
Flour bags, Triest	52
Forges, portable, carefully packed	60
Freestones	16
Fruit:	
Currants	50
Lemons	85
Melons	80
Onions	78
Oranges, boxes	90
Raisins	52
Fuel, patent	30–35
Fuel, oil	39–40
Furs, skins, in cases	130
Ginger	80
Glass, bottles	85
Glass, plate, in cases (uncertain)	41
Glassware in cases	110–200
Glass in crates	130
Granite, stone	14
Granite dressed, in block	16
Granite in cases	19
Gravel, coarse	23
Grease	65
Grindstones	57
Guano	42
Gum	50
Gunny bags	50
Gunnies, hard-pressed	48
Gunnies, ordinarily pressed	57
Gunpowder	50
Hair, pressed horse	140–175
Hair, ordinary horse	225
Hair, unpressed	360

STOWAGES OF MERCHANDISE. — (*Continued.*)

	Cubic Feet per Ton.
Hay compressed	105–125
Hay uncompressed	140
Hams, smoked, in barrels	70
Hemp in bales, Manila	73
Hemp in bales, Calcutta	57
Hemp, American and New Zealand	106
Hemp in bales, Italian	268
Hemp seed in bags	70
Herrings, cured, in barrels	60
Herrings, salted	45
Herrings, kippered in boxes	85
Hides in bales, dried and pressed	75–86
Hides in barrels, salted	50
Hides (dried skins) in bales	120
Hops in bales	260
Horns and hoofs	90–95
Ice	39
India rubber, raw, well-packed	68–70
Indigo in cases	62–66
Iron, pig, well-stowed	10
Iron, corrugated galvanized sheets	36
Iron, kegs of steel	21
Ivory, well-packed loose	28
Jaggery, damp, dirty sugar	34
Jute	58
Kaolin, China clay, in bags	40
Lard	70
Lard stearine, in bags	52
Lead, pig	8
Lead, pipes, variable	12
Leather in rolls	224
Leather in bales	90
Leather, tannery waste, in bales	185
Lemons (see Fruit)	
Lemon peel in casks	65
Linseed in bags	56–57
Locust beans in bulk	80–84
Logwood in bundles	92
Madder	75
Manure, phosphate	46
Manure, manufactured	40
Maize in bags	49–52
Maize in bulk	46–50

STOWAGES OF MERCHANDISE. — *(Continued.)*

	Cubic Feet per Ton.
Marl	28
Marble	14
Marble in slabs	17
Margarine in tubs	65–70
Matches	120
Meat:	
Beef, American salt, in tierces	52
Beef, packed, frozen	90–95
Beef, hung in quarters	120–130
Mutton, New Zealand	105–110
Mutton, River plate	115
Milk, condensed, in cases	45
Millet in bags	44–51
Mineral waters in cases	70
Mohair in bags	240
Molasses in puncheons	60–70
Molasses in bulk	25½
Mother-of-Pearl shells	45
Nitrate of soda	32
Nuts, shelled almonds, in bags	70
Nuts, shelled nuts, in casks	80
Nuts, shelled nuts, in casks	64
Brazil in barrels	90
Pistachio in cases	72
Walnuts in bales	182
Oak logs, planks of 50 feet	48
Oats in bags	75–80
Oats in bulk	61
Oatmeal in sacks	65
Oil, lubricating, in casks	60
Oil, sperm, in barrels	55
Oil, vegetable	66
Oil in bottles and baskets	96
Oil in drums	49
Oil in bottles, in cases	75
Oil in large drums	40
Oil cake in bags	46
Oil cake in bags, East Indian	60
Oil cake in bags, Mediterranean	54
Olives in casks	68
Onions in cases	78
Onions in bags	75
Opium in chests	96

STOWAGES OF MERCHANDISE. — (*Continued.*)

	Cubic Feet per Ton.
Oysters in barrels	60
Paint in drums	16
Paper in rolls	120
Peas in bags	50
Phosphate of lime	42
Pineapple, tinned, in cases	60
Pitch in barrels	45
Potatoes in bags	55
Potatoes in barrels	68
Prunes in casks	52
Quebrach	48
Rum in bottles and cases	66
Rape seed	61
Rice in bags	45–50
Rice meal	62
Rope	135
Rum in hogsheads	70
Rum in casks	60
Rye in bags	53
Sago	55
Salt in bulk	37
Salt in barrels	52
Saltpetre	36
Sand, pit (building)	22
Sand, river	21
Sandstone	14
Semolina in bags	60
Sewing machines in cases	81
Shellac	83
Shingle, clean	24
Silk, bales	100–128
Silk in cases	110–112
Slate	13
Slates in cases	24
Soap in boxes	46
Soda in bags	57
Soda in casks	54
Sponge	152
Starch in cases	80
Stone cargoes:	
Bath	16–17
Braigleith	15
Dundee	$13\frac{3}{4}$

STOWAGES OF MERCHANDISE. — (*Continued.*)

	Cubic Feet per Ton.
Stone cargoes:	
Granite, Quincy	15
Limestone, marble and purbeck	13¼
Portland stone	17
Welsh slate	13
Paving stone	15
Sugar, grape, in boxes	42
Sugar, Alexandria, in bags	46
Sugar in casks	60
Sugar in hogsheads	54
Sugar, refined, in bags	48
Sugar, ordinary, in bags	39–40
Sugar, raw, in baskets	50
Sugar, candy	54
Sulphur in bulk	27
Sulphur in cases	40
Sulphur in kegs	60
Sumac in bags	70
Syrup	34
Tallow in hogsheads	70
Tallow in barrels and tierces	58
Tamarinds in cases	40–47
Tamarinds in casks or kegs	54
Tan extract	48
Tapioca	57
Tar in barrels	54
Tares in bags	50
Tares in bulk	48
Tea, Indian in cases	100
Tea, China, in chests	100
Ties (steel railroad)	22
Ties (cast-iron pot)	37
Ties (steel broad gauge)	38
Ties (oak)	50
Tiles, roofing, in crates	85
Tiles, fire clay, in crates	50
Tiles, fire clay retorts, in bulk	48
Timber, flooring boards	75
Timber, oak	39
Timber, mahogany	34
Timber, ash	39
Timber, beech	51
Timber, elm	60

STOWAGES OF MERCHANDISE. — *(Concluded.)*

	Cubic Feet per Ton.
Timber, fir	65
Timber, greenheart	34
Timber, Baltic fir, squared	50
Timber, North American, fir, squared	51
Timber, deals, or battens	50
Tobacco in bales, Brazil	40
Tobacco in Yokohama	74
Tobacco, Turkish, in small bales	150
Tumeric	65–80
Turpentine in barrels	60
Vermicelli	110
Waste (see Cotton)	
Water, fresh	36
Water, salt	35
Wheat in bags	52
Wheat in bulk	46–48
Whitening in casks	39
Wool in sheets	260
Wool, New Zealand, dumped and greasy	84
Wool, New Zealand, scoured	100
Wool, Australian, undumped	236
Wool, Cape of Good Hope, in bales pressed, scoured	280
Wool, Australian, in bales	100
Wool, Australian, in double bales	113
Wool, Mediterranean, in bales half pressed and corded	200
Wool, Spanish bales, unpressed	212
Wool in bales, hydraulic pressed	100
Wool in bales, pressed wool waste	75

COLD STORAGE TEMPERATURES IN DEGREES FAHRENHEIT.

Ale	33–42	Grapes	32–40
Apples	32–36	Ginger ale	35–36
Apple and peach butter	40	Hams	20–35
Asparagus	33–35	Hogs	30–35
Bananas	34–35	Hops	32–40
Beans	32–40	Hops (frozen)	28
Beef (fresh)	35–39	Honey	36–45
Beer in casks	32–42	Lard	34–35
Beer in bottles	45	Lemons	33–45
Berries, fresh	35–40	Liver	30
Buckwheat flour	40–42	Maple syrup and sugar	40–45
Butter	14–38	Margarine	18–35
Butterine	20–35	Meat (brined)	35–40
Cabbages	32–35	Meat (canned)	30–35
Cantaloupes	40	Meat (fresh)	34–40
Carrots	33–35	Melons	35
Celery	32–35	Milk	32
Cheese	28–35	Mutton	33–36
Chestnuts	33–40	Mutton (frozen)	25–28
Chocolate to cool	40	Nuts in shell	35–40
Cider	32–40	Oatmeal	40–42
Cigars	35–42	Oleomargarine	20–35
Clarets	45–50	Oil	35–45
Corn meal	42	Onions	32–40
Cranberries	32–36	Oysters in tubs	25–35
Cream	35	Oysters in shells	33–43
Cucumbers	38–40	Oxtails	32
Currants	32	Parsnips	32–35
Dates	45–55	Peaches	34–55
Eggs	30–35	Pears	40–45
Ferns	28	Plums	32–40
Figs	35–55	Porter	33–42
Fish (fresh)	20–30	Pork	34
Fish (frozen)	14–17	Potatoes	34–40
Fish (canned)	35	Poultry (frozen)	20–30
Fish (dried)	35–40	Poultry (to freeze)	5–22
Fish (to freeze)	5	Poultry (long storage)	10
Flour	36–46	Sardines	35–40
Fruits	26–55	Sauerkraut	35–38
Fruits (dried)	35–40	Sausage casings	30–35
Fruits (canned)	30–35	Sugar	40–45
Furs (dressed)	25–32	Syrup	35–45
Furs (undressed)	35	Tenderloin	30–35

COLD STORAGE TEMPERATURES. — (*Continued.*)

Tomatoes	32–42	Watermelons	34–40
Tobacco	35–42	Wheat Flour	40–42
Veal	32–36	Wines	40–50
Vegetables	34–40	Woolens	25–35

THE DISTANCE IN NAUTICAL MILES BETWEEN COLON AND

	Miles.		Miles.
Acapulco	1426	New Orleans	1395
Antofagasta	2140	New York	1970
Bahia	3928	Norfolk	1781
Baltimore	1903	Para	2629
Boston	2144	Parahiba	3250
Buenos Aires	5768	Paramaribo	1750
Callao	1346	Pernambuco	3529
Caracas	841	Philadelphia	1949
Cartagena	281	Port au Prince	774
Cayenne	1930	Portland	3895
Charleston	1566	Quebec	3295
Desterro	4925	Rio de Janeiro	4609
Galveston	1499	Sabanilla	315
Georgetown	1864	St. Thomas	1029
Guayaquil	793	Salina Cruz	1170
Halifax	2570	San Diego	2843
Havana	1007	San Francisco	3245
Iquique	1987	San Salvador	840
Jacksonville	1518	Savannah	1565
Juneau	4945	Seattle	4076
Key West	1070	Sitka	4547
Kingston	546	Tampico	1491
Les Cayes	647	Valdivia	2983
Liverpool	4548	Valparaiso	2616
Manzanillo	1760	Vera Cruz	1426
Mazatlan	2060	Victoria, B. C.	4154
Montevideo	5646		

SECTION VII.

MATHEMATICAL TABLES.

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THE METRIC SYSTEM.

The principal advantage of the metric system consists in its use of the decimal subdivisions. The attempt to consider the metre as $\frac{1}{10,000,000}$ of a quadrant of the earth's surface has been abandoned, and it is now held only to be the length of the standard known as the *Mètre des Archives*, copies of which are issued by the *Bureau Internationale des Poids et Mésures*, at Breteuil, near Paris.

The kilogramme was originally intended to be the weight of a cubic decimetre or litre of pure water at the temperature of maximum density, but it is really now considered only as the weight of a platinum standard. At the same time, this relation between the unit of weight and a standard volume of water is sufficiently close for the specific gravity of any substance to be considered as equal to the weight of a cubic decimetre of that substance. In all hydraulic measurements a cubic metre of water is equal in weight to the metric tonne of 1000 kilogrammes, a most convenient fact in the determination of the power developed by a given fall and volume of water.

The French Metrical System.

The French units of weight, measure, and coin are arranged into a perfect decimal system, except those of time and the circle. The division and multiplication of the units are expressed by Latin and Greek names, as follows:

Latin, Division.

Milli	= 1000th of the unit.
Centi	= 100th of the unit.
Deci	= 10th of the unit.

Metre, litre, stere, are, franc, gramme.

Greek, Multiplication.

Deca	= 10 times the unit.
Hecato	= 100 times the unit.
Kilio	= 1000 times the unit.
Myrio	= 10000 times the unit.

French Measure of Length.

1 millimetre	= 0.03937 inch.
1 centimetre	= 0.3937 inch.
1 decimetre	= 3.937 inches.
1 metre (unit)	= 39.37 inches.
1 sea mile	= 1853.25 metres.
1 kilometre	= 0.53959 sea mile.

1 metre (unit)	= 3.28083 feet.
1 decametre	= 32.8083 feet.
1 hectometre	= 328.083 feet.
1 kilometre	= 3280.83 ft. = 0.62137 mile.
1 statute mile	= 1.60935 kilomets.
1 kilometre	= 49.7096 chains.

French Measure of Surface.

1 square metre	= 10.764 square feet.
1 are	= 100 square metres.
1 decare	= 10 ares.
1 hectare	= 100 ares.

1 are	= 1076.4 square feet.
1 decare	= 107.64 square feet.
1 hectare	= 2.471 Eng. acres.
1 square mile	= 259 hectares.

French Measure of Volume.

1 stere (cubic metre)	= 10 decasteres.
1 stere	= 1000 litres.
1 litre	= 1 cubic decimetre.
1 decistere	= 3.5314 cubic feet.

1 stere	= 35.314 Eng. cubic feet.
1 litre	= 61.023 Eng. cub. inches.
1 gallon	= 3.7854 litres.
1 decistere	= 2.838 bushels (nearly).

French Measure of Weight.

1 ton	= 1 cubic metre distilled water.
1 ton	= 1000 kilogrammes.
1 kilogramme	= 1000 grammes.
1 hectogramme	= *100 grammes.*
1 decagramme	= *10 grammes.*
1 gramme	= *1 cubic centimetre distilled water.*
1 French ton	= *0.9842 Eng. ton.*

1 gramme	= 10 decigrammes.
1 decigramme	= 10 centigrammes.
1 centigramme	= 10 milligrammes.
1 kilogramme	= 2.20462 pounds avoirdupois.
1 Eng. pound	= 0.45359 kilogra
1 gramme	= 15.43 grains tro
1 English ton	= 1.016 French ton

Conversion of English Inches into Centimetres.

Inches.	0	1	2	3	4	5	6	7	8	9
	Cm	Cm.	Cm.	Cm.	Cm.	Cm.	Cm.	Cm.	Cm.	Cm.
0	0.000	2.540	5.080	7.620	10.16	12.70	15.24	17.78	20.32	22.86
10	25.40	27.94	30.48	33.02	35.56	38.10	40.64	43.18	45.72	48.26
20	50.80	53.34	55.88	58.42	60.96	63.50	66.04	68.58	71.12	73.66
30	76.20	78.74	81.28	83.82	86.36	88.90	91.44	93.98	96.52	99.06
40	101.60	104.14	106.68	109.22	111.76	114.30	116.84	119.38	121.92	124.46
50	127.00	129.54	132.08	134.62	137 16	139.70	142.24	144.78	147.32	149.86
60	152.40	154.94	157.48	160.02	162.56	165.10	167.64	170.18	172.72	175.26
70	177.80	180.34	182.88	185.42	187 96	190.50	193.04	195.58	198.12	200.66
80	203.20	205.74	208.28	210.82	213.36	215.90	218.44	220.98	223.52	226.06
90	228.60	231.14	233.68	236.22	238.76	241.30	243.84	246.38	248.92	251.46
100	254.00	256.54	259.08	261.62	264.16	266.70	269.24	271.78	274.32	276.86

Conversion of Centimetres into English Inches.

Cm	0	1	2	3	4	5	6	7	8	9
	Inch	Inch	Inch	Inch.	Inch.	Inch.	Inch.	Inch	Inch	Inch.
0	0.000	0 394	0 787	1 181	1,575	1 969	2,362	2.756	3 150	3.543
10	3.937	4.331	4.742	5.118	5.512	5.906	6.299	6.693	7.087	7 480
20	7.874	8 268	8,662	9 055	9.449	9.843	10.236	10,630	11 024	11,418
30	11.811	12.205	12.599	12 992	13.386	13.780	14 173	14 567	14.961	15.355
40	15.748	16 142	16.536	16 929	17 323	17 717	18.111	18.504	18.898	19.292
50	19.685	20 079	20.473	20.867	21.260	21 654	22.048	22.441	22 835	23.229
60	23.622	24 016	24.410	24 804	25.197	25 591	25.985	26.378	26.772	27 166
70	27 560	27 953	28.347	28.741	29 134	29 528	29.922	30.316	30.709	31 103
80	31 497	31 890	32.284	32 678	33.071	33.465	33.859	34 253	34.646	35,040
90	35.434	35.827	36.221	36.615	37 009	37 402	37 796	38.190	38.583	38.977
100	39.370	39.764	40.158	40.552	40 945	41 339	41 733	42.126	42.520	42.914

Conversion of English Feet into Metres.

Feet	0	1	2	3	4	5	6	7	8	9
	Met.	Met.	Met.	Met.	Met.	Met.	Met.	Met.	Met.	Met.
0	0 000	0.3048	0 6096	0 9144	1 2192	1 5239	1.8287	2.1335	2.4383	2.7431
10	3.0479	3.3527	3.6575	3.9623	4 2671	4 5719	4 8767	5.1815	5.4863	5.7911
20	6.0959	6.4006	6 7055	7,0102	7 3150	7 6198	7 9246	8.2294	8.5342	8.8390
30	9.1438	9 4486	9.7534	10.058	10.363	10.668	10 972	11.277	11.582	11.887
40	12.192	12.496	12.801	13.106	13.411	13 716	14 020	14 325	14.630	14,935
50	15.239	15.544	15.849	16.154	16.459	16.763	17 068	17 373	17.678	17 983
60	18.287	18.592	18.897	19.202	19,507	19 811	20.116	20.421	20.726	21.031
70	21.335	21.640	21.945	22.250	22.555	22.859	23.164	23.469	23 774	24.079
80	24 383	24 688	24 993	25 298	25 602	25 907	26 212	26.517	26.822	27 126
90	27 431	27 736	28 041	28 346	28.651	28.955	29.260	29.565	29.870	30.174
100	30 479	30 784	31.089	31 394	31.698	32.003	32.308	32.613	32.918	33.222

Conversion of Metres into English Feet.

Metres.	0	1	2	3	4	5	6	7	8	9
	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
0	0.000	3.2809	6.5618	9.8427	13.123	16.404	19.685	22.966	26.247	29.528
10	32.809	36.090	39.371	42.651	45.932	49.213	52.494	55.775	59.056	62.337
20	65.618	68.899	72.179	75.461	78.741	82 022	85.303	88.584	91.865	95.146
30	98.427	101 71	104.99	108.27	111.55	114.83	118.11	121.39	124.67	127.96
40	131 24	134.52	137 80	141.08	144 36	147.64	150.92	154.20	157.48	160.76
50	164.04	167.33	170.61	173.89	177 17	180.45	183.73	187 01	190 29	193.57
60	196.85	200.13	203.42	206.70	209.98	213.26	216.54	219.82	223.10	226.38
70	229.66	232.94	236.22	239.51	242 79	246.07	249.35	252.63	[illegible]	[illegible]
80	262.47	265.75	269.03	272.31	275.60	278.88	282.16	285 44	288.72	[illegible]
90	295.28	298.56	301.84	305 12	308.40	311.69	314.97	318.25	[illegible]	[illegible]
100	328.09	331.37	334.65	337.93	341.21	344.49	347 78	351.06	354.34	[illegible]

Conversion of English Statute-miles into Kilometres.

Miles.	0	1	2	3	4	5	6	7	8	9
	Kilo.	Kilo.	Kilo.	Kilo.	Kilo.	Kilo.	Kilo.	Kilo.	Kilo.	Kilo.
0	0.0000	1.6093	3.2186	4.8279	6.4372	8.0465	9.6558	11.2652	12.8745	14.4848
10	16.093	17.702	19.312	20.921	22.530	24.139	25.749	27.358	28.967	30.577
20	32.186	33.795	35.405	37.014	38.623	40.232	41.842	43.451	45.060	46.670
30	48.279	49.888	51.498	53.107	54.716	56.325	57.935	59.544	61.153	62.763
40	64.372	65.981	67.591	69.200	70.809	72.418	74.028	75.637	77.246	78.856
50	80.465	82.074	83.684	85.293	86.902	88.511	90.121	91.730	93.339	94.949
60	96.558	98.167	99.777	101.39	102.99	104.60	106.21	107.82	109.43	111.04
70	112.65	114.26	115.87	117.48	119.08	120.69	122.30	123.91	125.52	127.13
80	128.74	130.35	131.96	133.57	135.17	136.78	138.39	140.00	141.61	143.22
90	144.85	146.44	148.05	149.66	151.26	152.87	154.48	156.09	157.70	159.31
100	160.93	162.53	164.14	165.75	167.35	168.96	170.57	172.18	173.79	175.40

Conversion of Kilometres into English Statute-miles.

Kilom.	0	1	2	3	4	5	6	7	8	9
	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.
0	0.0000	0.6214	1.2427	1.8641	2.4855	3.1069	3.7282	4.3497	4.9711	5.5924
10	6.2138	6.8352	7.4565	8.0780	8.6991	9.3208	9.9421	10.562	11.185	11.806
20	12.427	13.049	13.670	14.292	14.913	15.534	16.156	16.776	17.399	18.019
30	18.641	19.263	19.884	20.506	21.127	21.748	22.370	22.990	23.613	24.233
40	24.855	25.477	26.098	26.720	27.341	27.962	28.584	29.204	29.827	30.447
50	31.069	31.690	32.311	32.933	33.551	34.174	34.797	35.417	36.040	36.660
60	37.282	37.901	38.525	39.147	39.768	40.389	41.011	41.631	42.254	42.874
70	43.497	44.118	44.739	45.361	45.982	46.603	47.225	47.845	48.468	49.088
80	49.711	50.332	50.954	51.575	52.196	52.817	53.439	54.059	54.682	55.302
90	55.924	56.545	57.166	57.788	58.409	59.030	59.652	60.272	60.895	61.515
100	62.138	62.759	63.380	64.002	64.623	65.244	65.866	66.486	67.109	67.729

Conversion of Sea-miles into Kilometres.

Sea-miles.	0	1	2	3	4	5	6	7	8	9
	Kilo.	Kilo.	Kilo.	Kilo.	Kilo.	Kilo.	Kilo.	Kilo.	Kilo.	Kilo.
0	0.0000	1.8532	3.7046	5.5596	7.4128	9.2660	11.119	12.972	14.825	16.788
10	18.532	20.385	22.237	24.128	25.945	27.798	29.651	31.504	33.357	35.320
20	37.064	38.918	40.769	42.660	44.477	46.331	48.183	50.036	51.889	53.852
30	55.596	57.450	59.301	61.192	63.009	64.863	66.715	68.568	70.421	72.384
40	74.128	75.982	77.834	79.724	81.541	83.396	85.247	87.100	88.953	90.916
50	92.660	94.511	96.365	98.256	100.07	101.92	103.78	105.64	107.48	109.45
60	111.19	113.05	114.90	116.79	118.61	120.45	122.21	124.16	126.01	127.98
70	129.72	131.58	133.43	135.32	137.14	139.08	140.74	142.69	144.54	146.61
80	148.25	150.11	151.96	153.85	155.67	157.52	159.27	161.22	163.07	165.04
90	166.78	168.64	170.49	172.38	174.20	176.05	177.80	179.75	181.60	183.57
100	185.32	187.18	189.03	190.88	192.73	194.58	196.44	198.29	200.14	201.99

Conversion of Kilometres into Sea-miles.

Kilom.	0	1	2	3	4	5	6	7	8	9
	Sea-m.	Sea-m.	Sea-m.	Sea-m.	Sea-m.	Sea-m.	Sea-m.	Sea-m.	Sea-m.	Sea-m.
0	0.0000	0.5396	1.0792	1.6188	2.1584	2.6980	3.2375	3.7771	4.3167	4.8563
10	5.3959	5.9356	6.4751	7.0147	7.5543	8.0939	8.6334	9.1730	9.7126	10.252
20	10.792	11.331	11.870	12.410	12.950	13.480	14.029	14.568	15.108	15.647
30	16.188	16.727	17.265	17.806	18.345	18.876	19.424	19.965	20.504	21.044
40	21.584	22.123	22.661	23.202	23.740	24.271	24.819	25.360	25.900	26.439
50	26.980	27.519	28.059	28.598	29.135	29.667	30.214	30.757	31.296	31.835
60	32.375	32.915	33.456	33.994	34.530	35.063	35.609	36.151	36.692	37.231
70	37.771	38.310	38.852	39.390	39.925	40.459	41.004	41.674	42.088	42.827
80	43.167	43.705	44.284	44.786	45.320	45.855	46.399	46.943	47.483	48.022
90	48.563	49.103	49.644	50.182	50.715	51.251	51.794	52.339	52.879	53.419
100	53.959	54.498	55.038	55.575	56.117	56.656	57.198	57.737	58.275	58.816

Conversion of Square Inches into Square Centimetres.

Square in.	0	1	2	3	4	5	6	7	8	9
	Cm².	Cm².	Cm².	Cm².	Cm².	Cm².	Cm².	Cm².	Cm².	Cm².
0	0.0000	6.4515	12.903	19.354	25.806	32.257	38.709	45.160	51.612	58.063
10	64.515	70.967	77.418	83.869	90.321	96.772	103.22	109.67	116.12	122.57
20	129.03	135.48	141.93	148.38	154.83	161.29	167.74	174.19	180.64	187.09
30	193.54	199.99	206.44	212.89	219.34	225.80	232.25	238.70	245.15	251.60
40	258.06	264.51	270.96	277.41	283.86	290.32	296.77	303.22	309.67	316.12
50	322.57	329.02	335.47	341.92	348.37	354.83	361.28	367.73	374.18	380.63
60	387.09	393.54	399.99	406.44	412.89	419.35	425.80	432.25	438.70	445.15
70	451.60	458.05	464.50	470.95	477.40	483.86	490.31	496.76	503.21	509.66
80	516.12	522.57	529.02	535.47	541.92	548.38	554.83	561.28	567.73	574.18
90	580.63	587.08	593.53	599.98	606.43	612.89	619.34	625.79	632.24	638.69
100	645.15	651.60	658.05	664.50	670.95	677.41	683.86	690.31	696.76	703.21

Conversion of Square Centimetres into Square Inches.

Square cm.	0	1	2	3	4	5	6	7	8	9
	In².	In².	In².	In².	In².	In².	In².	In².	In².	In².
0	0.0000	0.1550	0.3100	0.4650	0.6200	0.7750	0.9300	1.0850	1.2400	1.3950
10	1.5500	1.7050	1.8600	2.0150	2.1700	2.3250	2.4800	2.6350	2.7900	2.9450
20	3.1000	3.2550	3.4100	3.5650	3.7200	3.8750	4.0300	4.1850	4.3400	4.4950
30	4.6501	4.8051	4.9601	5.1151	5.2701	5.4251	5.5801	5.7351	5.8901	6.0451
40	6.2001	6.3551	6.5101	6.6651	6.8201	6.9751	7.1301	7.2851	7.4401	7.5951
50	7.7501	7.9051	8.0601	8.2151	8.3701	8.5251	8.6801	8.8351	8.9901	9.1451
60	9.3002	9.4552	9.6102	9.7652	9.9202	10.075	10.230	10.385	10.540	10.695
70	10.850	11.005	11.160	11.315	11.470	11.625	11.780	11.935	12.090	12.245
80	12.400	12.555	12.710	12.865	13.020	13.175	13.330	13.485	13.640	13.795
90	13.950	14.105	14.260	14.415	14.570	14.725	14.880	15.035	15.190	15.345
100	15.500	15.655	15.810	15.965	16.120	16.275	16.430	16.585	16.740	16.895

Conversion of Cubic Inches into Cubic Centimetres.

Cubic in.	0	1	2	3	4	5	6	7	8	9
	Cm³.	Cm³.	Cm³.	Cm³.	Cm³.	Cm³.	Cm³.	Cm³.	Cm³.	Cm³.
0	0.0000	16.393	32.773	49.160	65.546	81.933	98.320	114.71	131.01	147.48
10	163.87	180.26	196.64	213.03	229.41	245.80	262.19	278.58	294.88	311.35
20	327.73	344.12	360.50	376.89	393.27	409.66	426.05	442.44	458.74	475.21
30	491.60	507.99	524.37	540.76	557.14	573.53	589.92	606.31	622.61	639.08
40	655.46	671.85	688.23	704.52	721.00	737.39	753.78	770.17	786.47	802.94
50	819.33	835.72	852.10	868.49	884.87	901.26	917.65	934.04	950.34	966.81
60	983.20	999.59	1016.0	1032.4	1048.7	1065.1	1081.5	1097.9	1114.2	1130.7
70	1147.1	1163.5	1179.9	1196.3	1212.6	1229.0	1245.4	1261.8	1278.1	1294.6
80	1310.9	1327.3	1343.7	1360.1	1376.4	1392.8	1409.2	1425.6	1441.9	1458.4
90	1474.8	1491.2	1507.6	1524.0	1540.3	1556.7	1573.1	1589.5	1605.8	1622.3
100	1638.7	1655.1	1671.5	1687.9	1704.2	1720.6	1737.0	1753.4	1769.7	1786.2

Conversion of Cubic Centimetres into Cubic Inches.

Cubic cm.	0	1	2	3	4	5	6	7	8	9
	In³.	In³.	In³.	In³.	In³.	In³.	In³.	In³.	In³.	In³.
0	0.0000	0.0610	0.1221	0.1831	0.2441	0.3051	0.3661	0.4272	0.4882	0.5492
10	0.6102	0.6712	0.7323	0.7933	0.8543	0.9153	0.9763	1.0374	1.0984	1.1594
20	1.2205	1.2815	1.3426	1.4036	1.4646	1.5256	1.5866	1.6477	1.7087	1.7697
30	1.8308	1.8918	1.9529	2.0139	2.0749	2.1359	2.1969	2.2580	2.3190	2.3800
40	2.4410	2.5020	2.5631	2.6241	2.6851	2.7461	2.8071	2.8682	2.9292	2.9902
50	3.0513	3.1123	3.1734	3.2344	3.2954	3.3564	3.4174	3.4785	3.5396	3.6005
60	3.6615	3.7225	3.7836	3.8446	3.9056	3.9666	4.0276	4.0887	4.1497	4.2107
70	4.2718	4.3328	4.3939	4.4549	4.5159	4.5769	4.6379	4.6990	4.7600	4.8210
80	4.8820	4.9430	5.0041	5.0651	5.1261	5.1871	5.2481	5.3092	5.3702	5.4312
90	5.4923	5.5533	5.6144	5.6754	5.7364	5.7974	5.8584	5.9195	5.9805	6.0415
100	6.1025	6.1635	6.2246	6.2856	6.3466	6.4076	6.4686	6.5297	6.5907	6.6517

Conversion of Cubic Yards into Cubic Metres.

Cubic yds.	0	1	2	3	4	5	6	7	8	9
	Met³	Met³	Met³	Met³.	Met³.	Met³	Met³	Met³	Met³	Met³.
0	0.0000	0.7645	1.5291	2.2936	3.0581	3.8226	4.5872	5.3517	6.1163	6.8808
10	7.6453	8.4098	9.1744	9.9389	10.703	11.468	12.232	12.997	13.761	14.526
20	15.291	16.055	16.820	17.584	18.349	19.114	19.878	20.643	21.407	22.172
30	22.936	23.701	24.466	25.230	25.994	26.759	27.523	28.288	29.052	29.817
40	30.581	31.346	32.110	32.875	33.639	34.404	35.168	35.933	36.697	37.462
50	38.227	38.990	39.756	40.520	41.284	42.049	42.813	43.578	44.342	45.107
60	45.872	46.636	47.401	48.165	48.930	49.695	50.459	51.224	51.988	52.753
70	53.517	54.281	55.046	55.811	56.575	57.340	58.104	58.869	59.633	60.398
80	61.163	61.927	62.692	63.457	64.221	64.986	65.750	66.515	67.279	68.044
90	68.808	69.572	70.337	71.102	71.866	72.631	73.395	74.160	74.924	75.689
100	76.453	77.217	77.982	78.747	79.511	80.276	81.040	81.805	82.569	83.334

Conversion of Cubic Metres into Cubic Yards.

Cubic met.	0	1	2	3	4	5	6	7	8	9
	Yds³	Yds³	Yds³	Yds³.	Yds³	Yds³.	Yds³	Yds³	Yds³	Yds³.
0	0.0000	1.3080	2.6160	3.9240	5.2329	6.5399	7.8477	9.1559	10.464	11.772
10	13.080	14.388	15.696	17.004	18.313	19.620	20.928	22.236	23.544	24.852
20	26.160	27.468	28.776	30.084	31.392	32.700	34.008	35.316	36.624	37.932
30	39.240	40.548	41.856	43.164	44.472	45.780	47.088	48.396	49.704	51.012
40	52.319	53.627	54.935	56.243	57.551	58.859	60.167	61.475	62.783	64.091
50	65.399	66.707	68.015	69.323	70.632	71.939	73.247	74.554	75.863	77.171
60	78.479	79.787	81.095	82.403	83.711	85.019	86.327	87.635	88.943	90.251
70	91.559	92.867	94.175	95.483	96.791	98.099	99.407	100.71	102.02	103.33
80	104.63	105.94	107.25	108.56	109.87	111.17	112.48	113.79	115.10	116.41
90	117.72	119.03	120.34	121.64	122.95	124.26	125.57	126.88	128.19	129.49
100	130.80	132.11	133.42	134.73	136.03	137.34	138.65	139.96	141.26	142.57

Conversion of U. S. Gallons into Litres.

Gallons.	0	1	2	3	4	5	6	7	8	9
	Litres.	Litres.	Litres.	Litres.	Litres.	Litres.	Litres.	Litres.	Litres.	Litres.
0	0.0000	3.7854	7.5709	11.356	15.142	18.927	22.713	26.497	30.283	34.068
10	37.854	41.639	45.425	49.210	52.996	56.781	60.567	64.352	68.138	71.923
20	75.709	79.494	83.279	87.065	90.850	94.636	98.421	102.21	105.99	109.77
30	113.56	117.35	121.13	124.92	128.70	132.49	136.27	140.06	143.84	147.63
40	151.42	155.20	158.99	162.77	166.56	170.34	174.13	177.92	181.70	185.49
50	189.27	193.06	196.84	200.63	204.41	208.20	211.98	215.77	219.55	223.34
60	227.12	230.91	234.70	238.48	242.27	246.05	249.84	253.62	257.41	261.19
70	264.98	268.76	272.55	276.33	280.12	283.90	287.69	291.47	295.26	299.04
80	302.83	306.62	310.40	314.19	317.97	321.76	325.54	329.33	333.11	336.90
90	340.69	344.47	348.26	352.04	355.83	359.62	363.40	367.19	370.97	374.75
100	378.54	382.33	386.11	389.90	393.68	397.47	401.26	405.04	408.83	412.61

Conversion of Litres into U. S. Gallons.

Litres.	0	1	2	3	4	5	6	7	8	9
	Gal.	Gal.	Gal.	Gal.	Gal.	Gal.	Gal.	Gal.	Gal.	Gal.
0	0.0000	0.2642	0.5284	0.7925	1.0567	1.3209	1.5851	1.8492	2.1134	2.3776
10	2.6418	2.9059	3.1701	3.4343	3.6985	3.9627	4.2268	4.4910	4.7552	5.0194
20	5.2836	5.5477	5.8119	6.0761	6.3403	6.6044	6.8686	7.1328	7.3970	7.6612
30	7.9253	8.1895	8.4537	8.7179	8.9821	9.2462	9.5104	9.7746	10.039	10.303
40	10.567	10.831	11.095	11.360	11.624	11.888	12.152	12.416	12.680	12.945
50	13.209	13.473	13.737	14.002	14.266	14.530	14.794	15.058	15.322	15.587
60	15.851	16.115	16.379	16.644	16.908	17.172	17.436	17.700	17.964	18.228
70	18.492	18.756	19.020	19.284	19.549	19.813	20.077	20.341	20.605	20.870
80	21.134	21.398	21.662	21.926	22.191	22.455	22.719	22.983	23.247	23.512
90	23.776	24.040	24.304	24.568	24.832	25.097	25.361	25.625	25.889	26.154
100	26.418	26.682	26.946	27.210	27.475	27.739	28.003	28.267	28.531	28.796

THE METRIC SYSTEM.

The principal advantage of the metric system consists in its use of the decimal subdivisions. The attempt to consider the metre as $\frac{1}{10,000,000}$ of a quadrant of the earth's surface has been abandoned, and it is now held only to be the length of the standard known as the *Mètre des Archives*, copies of which are issued by the *Bureau Internationale des Poids et Mésures*, at Breteuil, near Paris.

The kilogramme was originally intended to be the weight of a cubic decimetre or litre of pure water at the temperature of maximum density, but it is really now considered only as the weight of a platinum standard. At the same time, this relation between the unit of weight and a standard volume of water is sufficiently close for the specific gravity of any substance to be considered as equal to the weight of a cubic decimetre of that substance. In all hydraulic measurements a cubic metre of water is equal in weight to the metric tonne of 1000 kilogrammes, a most convenient fact in the determination of the power developed by a given fall and volume of water.

The French Metrical System.

The French units of weight, measure, and coin are arranged into a perfect decimal system, except those of time and the circle. The division and multiplication of the units are expressed by Latin and Greek names, as follows:

Latin, Division.		*Greek, Multiplication.*	
Milli	= 1000th of the unit.	Deca	= 10 times the unit.
Centi	= 100th of the unit.	Hecato	= 100 times the unit.
Deci	= 10th of the unit.	Kilio	= 1000 times the unit.
Metre, litre, stere, are, franc, gramme.		Myrio	= 10000 times the unit.

French Measure of Length.

1 millimetre	= 0.03937 inch.	1 metre (unit)	= 3.28083 feet.
1 centimetre	= 0.3937 inch.	1 decametre	= 32.8083 feet.
1 decimetre	= 3.937 inches.	1 hectometre	= 328.083 feet.
1 metre (unit)	= 39.37 inches.	1 kilometre	= 3280.83 ft. = 0.62137 mile.
1 sea mile	= 1853.25 metres.	1 statute mile	= 1.60935 kilomets.
1 kilometre	= 0.53959 sea mile.	1 kilometre	= 49.7096 chains.

French Measure of Surface.

1 square metre	= 10.764 square feet.	1 are	= 1076.4 square feet.
1 are	= 100 square metres.	1 decare	= 107.64 square feet.
1 decare	= 10 ares.	1 hectare	= 2.471 Eng. acres.
1 hectare	= 100 ares.	1 square mile	= 259 hectares.

French Measure of Volume.

1 stere (cubic metre)	= 10 decasteres.	1 stere	= 35.314 Eng. cubic feet.
1 stere	= 1000 litres.	1 litre	= 61.023 Eng. cub. inches.
1 litre	= 1 cubic decimetre.	1 gallon	= 3.7854 litres.
1 decistere	= 3.5314 cubic feet.	1 decistere	= 2.838 bushels (nearly).

French Measure of Weight.

1 ton	= 1 cubic metre distilled water.	1 gramme	= 10 decigrammes.
1 ton	= 1000 kilogrammes.	1 decigramme	= 10 centigrammes.
1 kilogramme	= 1000 grammes.	1 centigramme	= 10 milligrammes.
1 hectogramme	= 100 grammes.	1 kilogramme	= 2.20462 pounds avoirdupois.
1 decagramme	= 10 grammes.	1 Eng. pound	= 0.45359 kilograms.
1 gramme	= 1 cubic centimetre distilled water.	1 gramme	= 15.43 grains troy.
1 French ton	= 0.9842 Eng. ton.	1 English ton	= 1.016 French ton

Conversion of Cubic Feet into Cubic Decimetres.

Cubic feet.	0	1	2	3	4	5	6	7	8	9
	Dm³	Dm³	Dm³	Dm³.	Dm³	Dm³.	Dm³	Dm³.	Dm³	Dm³.
0	0.0000	28.316	56.632	84.948	113.26	141.58	169.90	198.21	226.53	254.84
10	283.16	311.47	339.79	368.11	396.42	424.74	453.06	481.37	509.69	538.00
20	566.32	594.64	622.95	651.27	679.58	707.90	736.22	764.53	792.85	821.16
30	849.48	877.80	906.11	934.43	962.74	991.06	1019.4	1047.7	1076.0	1104.3
40	1132.6	1160.8	1189.2	1217.5	1245.9	1274.2	1302.5	1330.8	1359.1	1387.4
50	1415.8	1444.0	1472.4	1500.7	1529.1	1557.4	1585.7	1614.0	1642.3	1670.6
60	1698.9	1727.2	1755.5	1783.8	1812.2	1840.5	1868.8	1897.1	1925.4	1953.7
70	1982.1	2010.4	2038.7	2067.0	2095.4	2123.7	2152.0	2180.3	2208.6	2236.9
80	2265.3	2293.5	2321.9	2350.2	2378.6	2406.9	2435.2	2463.5	2491.8	2520.1
90	2548.4	2576.6	2605.0	2633.3	2661.6	2690.0	2718.3	2746.6	2774.9	2803.2
100	2831.6	2859.8	2888.2	2916.5	2944.9	2973.2	3001.5	3029.8	3058.1	3086.4

Conversion of Cubic Decimetres into Cubic Feet.

Cubic dm	0	1	2	3	4	5	6	7	8	9
	Ft³.	Ft³.	Ft³	Ft³.	Ft³	Ft³.	Ft³.	Ft³.	Ft³.	Ft³.
0	0.0000	0.0353	0.0706	0.1059	0.1413	0.1766	0.2119	0.2472	0.2825	0.3178
10	0.3531	0.3884	0.4237	0.4590	0.4944	0.5297	0.5540	0.6003	0.6456	0.6709
20	0.7063	0.7416	0.7769	0.8122	0.8476	0.8829	0.9182	0.9535	0.9888	1.0241
30	1.0594	1.0947	1.1300	1.1653	1.2007	1.2360	1.2713	1.3066	1.3419	1.3772
40	1.4126	1.4479	1.4832	1.5185	1.5539	1.5892	1.6245	1.6598	1.6951	1.7304
50	1.7658	1.8011	1.8364	1.8717	1.9071	1.9424	1.9777	2.0130	2.0483	2.0836
60	2.1189	2.1542	2.1895	2.2248	2.2602	2.2955	2.3308	2.3661	2.4014	2.4367
70	2.4721	2.5074	2.5427	2.5780	2.6134	2.6487	2.6840	2.7193	2.7546	2.7899
80	2.8252	2.8605	2.8958	2.9311	2.9665	3.0018	3.0371	3.0724	3.1077	3.1430
90	3.1784	3.2137	3.2490	3.2843	3.3197	3.3550	3.3903	3.4256	3.4609	3.4962
100	3.5315	3.5668	3.6021	3.6374	3.6728	3.7081	3.7434	3.7787	3.8140	3.8493

Pounds per Square Foot into Kilogrammes per Square Metre.

Lbs. pr ft².	0	1	2	3	4	5	6	7	8	9
	K. m².	K. m².	K. m².	K. m².	K. m².	K. m².	K. m².	K. m².	K. m².	K. m².
0	0.0000	4.8825	9.7650	14.647	19.530	24.413	29.295	34.177	39.006	43.943
10	48.825	53.707	58.590	63.472	68.355	73.238	78.120	83.002	87.831	92.768
20	97.650	102.53	107.41	112.30	117.18	122.06	126.94	131.83	136.66	141.59
30	146.47	151.35	156.23	161.12	165.90	170.88	175.76	180.65	185.47	190.41
40	195.30	200.13	205.06	209.95	214.83	219.71	224.59	229.48	234.30	239.24
50	244.13	249.01	253.89	258.78	263.66	268.54	273.42	278.31	283.13	288.06
60	292.95	297.83	302.71	307.60	312.48	317.36	322.24	327.13	331.95	336.89
70	341.77	346.65	351.53	356.42	361.20	366.18	371.06	375.95	380.77	385.71
80	390.06	394.94	399.82	404.71	409.59	414.47	419.35	424.24	429.06	434.00
90	439.43	444.31	449.19	454.08	458.96	463.34	468.72	473.61	478.43	483.37
100	488.25	493.13	498.01	502.90	507.78	512.66	517.54	522.43	527.25	532.19

Kilogrammes per Square Metre into Pounds per Square Foot.

K. per m².	0	1	2	3	4	5	6	7	8	9
	Lb. ft²	Lb. ft²	Lb. ft²	Lb. ft²	Lb. ft²	Lb. ft²	Lb. ft²	Lb. ft²	Lb. ft²	Lb. ft²
0	0.0000	0.2048	0.4096	0.6144	0.8192	1.0240	1.2289	1.4337	1.6385	1.8433
10	2.0481	2.2529	2.4577	2.6625	2.8673	3.0721	3.2770	3.4818	3.6866	3.8914
20	4.0962	4.3010	4.5058	4.7106	4.9154	5.1202	5.3251	5.5299	5.7347	5.9395
30	6.1444	6.3492	6.5540	6.7588	6.9636	7.1684	7.3732	7.5781	7.7829	7.9877
40	8.1925	8.3973	8.6021	8.8069	9.0117	9.2165	9.4214	9.6262	9.8310	10.036
50	10.240	10.445	10.650	10.854	11.059	11.264	11.469	11.674	11.878	12.083
60	12.288	12.493	12.698	12.902	13.107	13.312	13.517	13.722	13.927	14.132
70	14.337	14.542	14.746	14.951	15.156	15.361	15.566	15.771	15.975	16.180
80	16.385	16.590	16.794	16.999	17.204	17.409	17.614	17.819	18.023	18.228
90	18.433	18.638	18.842	19.047	19.252	19.457	19.662	19.867	20.071	20.276
100	20.481	20.686	20.890	21.095	21.300	21.505	21.710	21.915	22.119	22.324

Pounds per Square Inch into Atmospheric Pressure.

Lbs. per in²	0	1	2	3	4	5	6	7	8	9
	At.	At.	At.	At.	At.	At.	At.	At.	At.	At.
0	0.0000	0.0680	0.1361	0.2041	0.2722	0.3402	0.4082	0.4763	0.5443	0.6124
10	0.6804	0.7484	0.8165	0.8845	0.9526	1.0206	1.0886	1.1567	1.2247	1.2928
20	1.3608	1.4288	1.4969	1.5649	1.6330	1.7010	1.7690	1.8371	1.9051	1.9732
30	2.0413	2.1093	2.1774	2.2454	2.3135	2.3814	2.4495	2.5176	2.5856	2.6537
40	2.7217	2.7897	2.8578	2.9258	2.9939	3.0619	3.1299	3.1980	3.2660	3.3341
50	3.4021	3.4701	3.5382	3.6062	3.6743	3.7423	3.8103	3.8784	3.9464	4.0145
60	4.0825	4.1505	4.2186	4.2866	4.3547	4.4227	4.4907	4.5588	4.6268	4.6949
70	4.7630	4.8310	4.8991	4.9671	5.0352	5.1031	5.1712	5.2393	5.3073	5.3754
80	5.4434	5.5114	5.5795	5.6475	5.7156	5.7836	5.8516	5.9197	5.9877	6.0558
90	6.1238	6.1918	6.2599	6.3279	6.3960	6.4640	6.5320	6.6001	6.6681	6.7362
100	6.8042	6.8722	6.9403	7.0083	7.0764	7.1444	7.2124	7.2805	7.3485	7.4166

Atmospheric Pressure into Pounds per Square Inch.

Atm. pres.	0	1	2	3	4	5	6	7	8	9
	Lb. in²	Lb. in²	Lb. in²	Lb. in²	Lb. in²	Lb. in²	Lb. in²	Lb. in²	Lb. in²	Lb. in²
0	0.0000	14.697	29.394	44.090	58.787	73.483	88.180	102.87	117.57	132.27
10	146.97	161.67	176.36	191.06	205.76	220.45	235.15	249.84	264.54	279.24
20	293.93	308.63	323.32	338.02	352.72	367.41	382.11	396.80	411.50	426.20
30	440.90	455.60	470.29	484.99	499.69	514.38	529.08	543.77	558.47	573.17
40	587.87	602.57	617.26	631.96	646.66	661.35	676.05	690.74	705.44	720.14
50	734.84	749.53	764.22	778.92	793.62	808.31	823.01	837.70	852.40	867.10
60	881.80	896.50	911.19	925.89	940.59	955.28	969.98	984.67	999.37	1014.1
70	1028.7	1043.4	1058.1	1072.8	1087.5	1102.2	1116.9	1131.6	1146.3	1161.0
80	1175.7	1190.4	1205.1	1219.8	1234.5	1249.2	1263.9	1278.6	1293.3	1308.0
90	1322.7	1337.4	1352.1	1366.8	1381.5	1396.2	1410.9	1425.6	1440.3	1455.0
100	1469.7	1484.4	1499.1	1513.8	1528.5	1543.2	1557.9	1572.6	1587.3	1602.0

Pounds per Square Inch into Kilogrammes per Square Centimetre.

Lbs. per in²	0	1	2	3	4	5	6	7	8	9
	K. cm²	K. cm²	K. cm²	K. cm²	K. cm²	K. cm²	K. cm²	K. cm²	K. cm²	K. cm²
0	0.0000	0.0703	0.1406	0.2109	0.2812	0.3515	0.4218	0.4921	0.5625	0.6328
10	0.7031	0.7734	0.8437	0.9140	0.9843	1.0546	1.1249	1.1952	1.2655	1.3358
20	1.4062	1.4765	1.5468	1.6171	1.6874	1.7577	1.8280	1.8983	1.9686	2.0389
30	2.1092	2.1795	2.2498	2.3202	2.3905	2.4608	2.5311	2.6014	2.6717	2.7420
40	2.8123	2.8826	2.9529	3.0232	3.0935	3.1639	3.2342	3.3045	3.3748	3.4451
50	3.5154	3.5857	3.6560	3.7263	3.7966	3.8669	3.9372	4.0075	4.0779	4.1482
60	4.2185	4.2888	4.3591	4.4294	4.4997	4.5700	4.6403	4.7106	4.7809	4.8512
70	4.9216	4.9919	5.0622	5.1325	5.2028	5.2731	5.3434	5.4137	5.4840	5.5543
80	5.6246	5.6949	5.7652	5.8356	5.9059	5.9762	6.0465	6.1168	6.1871	6.2574
90	6.3277	6.3980	6.4683	6.5386	6.6089	6.6793	6.7496	6.8199	6.8902	6.9605
100	7.0308	7.1011	7.1714	7.2417	7.3120	7.3823	7.4526	7.5229	7.5933	7.6636

Kilogrammes per Square Centimetre into Pounds per Square Inch.

K. per cm²	0	1	2	3	4	5	6	7	8	9
	Lb. in²	Lb. in²	Lb. in²	Lb. in²	Lb. in²	Lb. in²	Lb. in²	Lb. in²	Lb. in²	Lb. in²
0	0.0000	14.223	28.446	42.670	56.893	71.116	85.339	99.562	113.78	128.01
10	142.23	156.45	170.68	184.90	199.12	213.35	227.57	241.79	256.02	270.24
20	284.46	298.68	312.91	327.13	341.35	355.58	369.80	384.02	398.25	412.47
30	426.70	440.92	455.14	469.36	483.59	497.81	512.03	526.26	540.48	554.70
40	568.93	583.15	597.37	611.60	625.82	640.04	654.27	668.49	682.71	696.94
50	711.16	725.38	739.61	753.83	768.05	782.28	796.50	810.72	824.95	839.17
60	853.39	867.61	881.84	896.06	910.28	924.51	938.73	952.95	967.18	981.40
70	995.63	1009.8	1024.1	1038.3	1052.5	1066.7	1081.0	1095.2	1109.4	1123.6
80	1137.8	1152.1	1166.3	1180.5	1194.7	1209.0	1223.2	1237.4	1251.6	1265.9
90	1280.1	1294.3	1308.5	1322.7	1337.0	1351.2	1365.4	1379.6	1393.9	1408.1
100	1422.3	1436.5	1450.8	1465.0	1479.2	1493.4	1507.7	1521.9	1536.1	1550.3

Conversion of English Pounds into Kilogrammes.

Eng. lbs.	0	1	2	3	4	5	6	7	8	9
	Kilo.	Kilo.	Kilo.	Kilo.	Kilo.	Kilo.	Kilo.	Kilo.	Kilo.	Kilo.
0	0.000	0.453	0.907	1.361	1.814	2.268	2.722	3.175	3.629	4.082
10	4.536	4.989	5.443	5.897	6.350	6.804	7.258	7.711	8.165	8.618
20	9.072	9.525	9.979	10.43	10.89	11.34	11.79	12.25	12.70	13.15
30	13.61	14.06	14.52	14.97	15.42	15.88	16.33	16.78	17.24	17.69
40	18.14	18.59	19.05	19.50	19.95	20.41	20.86	21.31	21.77	22.22
50	22.68	23.13	23.59	24.04	24.49	24.95	25.40	25.85	26.31	26.76
60	27.22	27.67	28.13	28.58	29.03	29.49	29.94	30.39	30.85	31.30
70	31.75	32.20	32.66	33.11	33.56	34.02	34.47	34.92	35.38	35.83
80	36.29	36.74	37.20	37.65	38.10	38.56	39.01	39.46	39.92	40.37
90	40.82	41.27	41.73	42.18	42.63	43.09	43.54	43.99	44.45	44.90
100	45.36	45.81	46.27	46.72	47.17	47.63	48.08	48.53	48.99	49.44

Conversion of Kilogrammes into English Pounds.

Fr. kilo.	0	1	2	3	4	5	6	7	8	9
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
0	0.000	2.205	4.410	6.615	8.820	11.02	13.23	15.43	17.64	19.84
10	22.05	24.25	26.46	28.67	30.87	33.07	35.28	37.48	39.69	41.89
20	44.10	46.30	48.51	50.72	52.92	55.12	57.33	59.53	61.74	63.94
30	66.15	68.35	70.56	72.77	74.97	77.17	79.38	81.58	83.79	85.99
40	88.20	90.40	92.61	94.82	97.02	99.22	101.4	103.6	105.8	108.0
50	110.2	112.5	114.6	116.8	119.0	121.2	123.4	125.6	127.8	130.0
60	132.3	134.5	136.7	138.9	141.1	143.3	145.5	147.7	149.9	152.1
70	154.3	156.5	158.7	160.9	163.1	165.3	167.5	169.7	171.9	174.1
80	176.4	178.6	180.8	183.0	185.2	187.4	189.6	191.8	194.0	196.2
90	198.4	200.6	202.8	205.0	207.2	209.4	211.6	213.8	216.0	218.2
100	220.5	222.7	224.9	227.1	229.3	231.5	233.7	235.9	238.1	240.3

Conversion of English Tons into Metric Tons.

Eng. tons.	0	1	2	3	4	5	6	7	8	9
	M. ton	M. ton	M. ton	M. ton	M. ton	M. ton	M. ton	M. ton	M. ton	M. ton
0	0.000	1.016	2.032	3.048	4.064	5.080	6.096	7.112	8.128	9.144
10	10.16	11.18	12.19	[illegible]	14.12	[illegible]	16.26	17.27	18.29	19.30
20	20.32	[illegible]	22.35	[illegible]	24.38	25.40	26.42	27.43	28.45	29.46
30	30.48	31.50	32.51	33.53	34.54	35.56	36.58	37.59	38.61	39.62
40	40.64	41.66	42.67	43.69	44.70	[illegible]	46.74	47.75	48.77	49.78
50	50.80	51.82	[illegible]	53.85	54.86	55.88	56.90	57.90	58.93	59.94
60	60.96	61.97	62.99	64.01	65.02	66.04	67.06	68.07	69.09	70.10
70	71.12	72.14	73.15	74.17	75.18	76.20	[illegible]	78.23	79.25	80.26
80	81.28	82.29	83.31	84.33	85.34	86.36	87.38	88.39	89.41	90.42
90	91.44	92.46	93.47	94.49	95.50	96.52	97.54	98.55	99.57	100.6
100	101.6	[illegible]	[illegible]	104.6	105.7	106.7	107.7	108.7	109.7	110.7

Conversion of Metric Tons into English Tons.

Fr. m. ton.	0	1	2	3	4	5	6	7	8	9
	E. ton	E. ton	E. ton	E. ton	E. ton	E. ton	E. ton	E. ton	E. ton	E. ton
0	0.000	0.984	1.969	2.953	3.937	[illegible]	5.906	6.890	7.874	8.858
10	9.843	10.83	11.81	[illegible]	[illegible]	14.76	15.75	16.73	17.72	18.70
20	19.69	20.67	21.66	22.64	23.63	[illegible]	25.60	26.58	27.56	28.55
30	29.53	[illegible]	31.50	32.48	[illegible]	[illegible]	[illegible]	36.42	37.40	38.39
40	[illegible]	[illegible]	41.34	42.32	[illegible]	44.29	45.28	46.26	47.24	48.23
50	[illegible]	[illegible]	51.18	[illegible]	53.15	[illegible]	55.12	56.10	57.09	58.07
60	59.06	60.04	61.03	62.01	63.00	63.98	64.97	65.95	66.93	67.92
70	68.90	69.88	70.87	71.85	72.84	73.82	74.81	75.79	76.77	77.76
80	78.74	79.72	80.71	81.69	82.68	83.66	84.65	85.63	86.61	87.60
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	94.48	95.47	96.45	97.44

Conversion of English Ounces Avoirdupois into French Grammes.

Eng. ozs.	0	1	2	3	4	5	6	7	8	9
	Grams	Grams	Grams	Grams	Grams	Grams	Grams	Grams	Grams	Grams
0	0.0000	28.348	56.697	85.046	113.39	141.74	170.09	198.44	226.79	235.14
10	283.49	311.83	340.18	368.52	396.87	425.22	453.57	481.92	510.27	538.62
20	566.97	595.32	623.67	652.01	680.36	708.71	737.06	765.41	793.76	822.11
30	850.46	878.81	907.16	935.50	963.85	992.20	1020.5	1048.9	1077.2	1105.6
40	1133.9	1162.2	1190.6	1218.9	1247.3	1275.6	1304.0	1332.3	1360.7	1389.0
50	1417.4	1445.7	1474.1	1502.4	1530.8	1559.1	1587.5	1615.8	1644.2	1672.5
60	1700.9	1729.2	1756.6	1785.9	1814.3	1842.9	1871.0	1899.3	1927.7	1956.0
70	1984.4	2012.7	2041.1	2079.4	2097.8	2126.1	2154.5	2182.8	2211.2	2239.5
80	2267.9	2296.2	2324.6	2352.9	2381.3	2409.6	2438.0	2466.3	2494.7	2523.0
90	2551.4	2579.7	2608.1	2636.4	2664.8	2693.1	2721.5	2739.8	2778.2	2806.5
100	2834.8	2863.1	[redacted]1.5	2919.8	2948.2	2976.5	3004.9	3033.2	3061.6	3089.9

Conversion of French Grammes into English Ounces Avoirdupois.

Fr. grams.	0	1	2	3	4	5	6	7	8	9
	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.
0	0.0000	0.0353	0.0705	0.1058	0.1411	0.1764	0.2116	0.2469	0.2822	0.3175
10	0.3527	0.3880	0.4232	[illegible]	0.4938	0.5291	[illegible]	0.5996	0.6349	0.6702
20	0.7055	[illegible]	[illegible]	0.8113	0.8466	0.8821	0.9171	0.9524	0.9877	1.0230
30	1.0582	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.3404	1.3757
40	1.4110	1.4462	[illegible]	[illegible]	[illegible]	1.5878	1.6226	1.6579	1.6932	1.7285
50	1.7637	1.7990	1.8342	1.874	1.9048	[illegible]	[illegible]	[illegible]	2.0459	2.0862
60	2.1164	[illegible]	2.1870	2.2222	2.2575	2.2928	2.3281	2.3634	2.3987	2.4340
70	2.4692	[illegible]	2.5397	2.5750	2.6103	2.6456	2.6808	2.7161	2.7514	2.7867
80	2.8220	[illegible]	2.8922	2.9278	2.9631	2.9984	3.0336	3.0689	3.1042	3.1395
90	3.1747	3.2100	3.2452	3.2806	3.3158	3.3511	3.3864	3.4216	3.4569	3.4922
100	3.5275	3.5628	3.5980	3.6333	3.6686	3.704	3.7391	3.7744	3.8097	3.8450

Conversion of English Grains Troy into French Grammes.

Eng. grains.	0	1	2	3	4	5	6	7	8	9
	Grams	Grams	Grams	Grams	Grams	Grams	Grams	Grams	Grams	Grams
0	0.0000	[illegible]	0.1296	0.1944	[illegible]	0.3240	0.3888	0.4535	0.5183	0.5832
10	0.6479	[illegible]	[illegible]	0.8423	0.9071	0.9714	1.0367	1.1014	1.1662	1.2310
20	1.2959	[illegible]	[illegible]	1.4903	[illegible]	[illegible]	1.6847	1.7494	1.814	1.8790
30	1.9438	[illegible]	2.0734	2.1382	[illegible]	[illegible]	[illegible]	[illegible]	2.4621	[illegible]
40	2.5918	[illegible]	2.7214	[illegible]	[illegible]	2.9158	2.9806	3.0454	3.1101	3.1749
50	3.2398	[illegible]	3.3694	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.7581	3.8229
60	3.8877	[illegible]	4.017	4.0821	4.1469	4.2117	4.2765	[illegible]	4.4060	4.4708
70	4.5357	4.6005	4.6653	4.7301	4.7949	4.8597	4.921	4.9892	5.0540	5.1190
80	5.1838	[illegible]	[illegible]	5.3782	[illegible]	[illegible]	[illegible]	5.6771	[illegible]	5.7667
90	5.8316	5.8964	5.9612	6.0260	[illegible]	6.1556	6.2204	6.2851	6.3499	6.4147
100	6.4795	6.5444	6.6091	6.6739	6.7387	6.8035	6.8683	6.9330	6.9978	7.0626

Conversion of French Grammes into English Grains Troy.

Fr. grams.	0	1	2	3	4	5	6	7	8	9
	Grs.	Grs.	Grs.	Grs.	Grs.	Grs.	Grs.	Grs.	Grs.	Grs.
0	0.0000	15.433	30.865	46.298	61.732	77.165	92.599	108.03	123.46	138.90
10	154.33	169.76	185.19	200.6	216.0	231.49	246.9	262.36	277.79	293.23
20	308.66	324.09	[illegible]	354.9	[illegible]	[illegible]	401.25	416.69	432.12	447.56
30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	601.89
40	617.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	740.78	[illegible]
50	771.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	895.11	910.55
60	925.99	941.42	[illegible]	972.29	[illegible]	[illegible]	1018.6	1034.0	[illegible]	[illegible]
70	[illegible]	1095.7	1111.2	1126.6	1142.0	1157.5	1172.9	[illegible]	1203.7	1219.2
80	1234.6	1250.0	1265.5	1280.9	1296.3	1311.8	1327.2	1342.6	1358.1	1373.5
90	1389.0	1404.4	1419.8	1435.3	1450.7	1466.1	1481.6	1497.0	1512.4	1527.9
100	1543.3	1558.7	1574.1	1589.6	1605.0	1620.4	1635.9	1651.3	1666.7	1682.2

Horse-power into Cheval-vapeur.

H.-power.	0	1	2	3	4	5	6	7	8	9
	C.-v.	C.-v.	C.-v.	C.-v.	C.-v.	C.-v.	C.-v.	C.-v.	C.-v.	C.-v.
0	[illegible]	1.0136	2.0272	3.0408	4.0544	5.0680	6.0816	7.0952	8.1088	9.1224
10	10.136	11 150	12.163	13.176	14 190	15 204	16.218	17 231	18.245	19.258
20	20.272	21 308	22.299	23.313	24.326	25 340	26.354	27.367	28.381	29.394
30	30.408	31 422	32.435	33.449	34 462	35 476	36 490	37.503	38 517	[illegible]
40	40.544	41.557	42.571	43 585	44.598	45 612	46.626	47 639	48 653	49.666
50	50.680	51 693	52 707	53 721	54 734	55.748	56 762	57 775	58 789	59 802
60	60.816	61 829	62.843	63 857	64 870	65.884	66.898	67 911	68 925	69.938
70	70.952	71 965	72 979	73 993	75 006	76 020	77.034	78.047	79 061	80.074
80	81.088	82 102	83.115	84.129	85.142	86.156	87 170	88.183	89.197	90.210
90	91.224	92.338	93.251	94.265	95.278	96.292	97.306	98.319	99 333	100.34
100	101.36	102.37	103 30	104.40	105.41	106.43	107 44	108.45	109.47	110.48

Cheval-vapeur into Horse-power.

Chev.-vap.	0	1	2	3	4	5	6	7	8	9
	H.-p.	H.-p.	H.-p.	H.-p.	H.-p.	H.-p.	H.-p.	H.-p.	H.-p.	H.-p.
0	0.0000	0 9863	1 9726	2.9589	3.9452	4 9315	5.9178	6 9041	7.8904	8.8767
10	9.8630	10.849	11.835	12.822	13.808	14 794	15.781	16.767	17 753	18.739
20	19.726	20 712	21 698	22 685	23.671	24 657	25.644	26.630	27.616	28 602
30	29.589	30 575	31 561	32.548	33 534	34 520	35.507	36.493	37 479	38.465
40	39.452	40 438	41 424	42.411	43 397	44.383	45 370	46.356	47 342	48.328
50	49.315	50 301	51 287	52.274	53.260	54 246	55.233	56 219	57 205	58.191
60	59.178	60 164	61 150	62.137	63.123	64 109	65 096	66 082	67.068	68.054
70	69.041	70 027	71 013	71 990	72.986	73 972	74 959	75 945	76.941	77 917
80	78.904	79 890	80 876	81 863	82.849	83 835	84 822	85 808	86.794	87 780
90	88.767	89 753	90 739	91 726	92.712	93.698	94 785	95 671	96.657	97.643
100	98.630	99 616	100.60	101.59	102.57	103 56	104 56	105.53	106.52	107.50

Foot-pounds into Kilogrammetres.

Foot-lbs.	0	1	2	3	4	5	6	7	8	9
	Kgm.	Kgm.	Kgm.	Kgm.	Kgm.	Kgm.	Kgm.	Kgm.	Kgm.	Kgm.
0	0.0000	0 1382	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1 1056	1 2439
10	1 3825	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2 4870	2 6259
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3 8696	4 0078
30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5 2517	[illegible]
40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6 7718
50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10 779	10 918
80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12 161	12 300
90	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13 544	13 682
100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14 511	14 649	[illegible]	14.925	14 064

Kilogrammetres into Foot-pounds.

Kgm.	0	1	2	3	4	5	6	7	8	9
	Ft.-lb.	Ft.-lb.	Ft.-lb.	Ft.-lb.	Ft.-lb.	Ft.-lb.	Ft.-lb.	Ft.-lb.	Ft.-lb.	Ft.-lb.
0	0.0000	7 2334	14 467	21 700	28.934	36 166	43 400	50 734	57.868	65.100
10	72.334	79 567	87 101	94 034	101 27	108 50	115.74	123 07	130 20	137 43
20	144 67	151 90	158 43	166 37	173 60	180 84	188.08	195 40	202 54	209 77
30	217 01	224.25	231 77	238 70	245 93	253 17	260.41	267 73	274 87	282.10
40	289.31	296 57	304 11	311 04	318 27	325 50	332.7[illegible]	340 07	347 21	354 44
50	361 66	368 89	376 43	383.36	390 59	397 82	405 07	412.39	419 53	426.76
60	434 00	441 23	448 77	455 70	462 93	470 17	477 41	484.73	491 87	499 10
70	507.34	514 57	522.11	529 04	536 27	543 50	550 75	558.07	565 21	572.44
80	578.68	585.91	593.45	599 38	607 61	614.85	622 09	629 41	636.55	643.78
90	651 00	658.23	665 77	672 70	679 93	687.17	694 41	701 74	708.87	716.10
100	723.31	730.57	738.11	745.04	752.27	759.51	766 75	774 07	781 21	788.44

Conversion of Foot-tons into Tonnes-metres.

Foot-tons.	0	1	2	3	4	5	6	7	8	9
	T.-m.	T.-m.	T.-m.	T.-m.	T.-m.	T.-m.	T.-m.	T.-m.	T.-m.	T.-m.
0	0.0000	0.3097	0.6194	0.9291	1.2388	1.5484	1.8581	2.1678	2.4775	2.7872
10	3.0969	3.4066	3.7163	4.0260	4.3356	4.6453	4.9550	5.2647	5.5744	5.8841
20	6.1938	6.5035	6.8132	7.1229	7.4325	7.7422	8.0519	8.3616	8.6713	8.9810
30	9.2906	9.6003	9.9100	10.219	10.529	10.839	11.149	11.460	11.768	12.078
40	12.387	12.697	13.006	13.316	13.626	13.935	14.245	14.557	14.864	15.174
50	15.484	15.794	16.103	16.413	16.723	17.032	17.342	17.654	17.961	18.271
60	18.581	18.891	19.200	19.510	19.820	20.129	20.439	20.751	21.058	21.368
70	21.678	21.988	22.297	22.607	22.917	23.226	23.536	23.848	24.155	24.465
80	24.775	25.085	25.394	25.704	26.014	26.323	26.633	26.945	27.252	27.562
90	27.872	28.182	28.491	28.801	29.111	29.420	29.730	30.042	30.349	30.659
100	30.969	31.279	31.588	31.898	32.208	32.517	32.827	33.139	33.446	33.756

Conversion of Tonnes-metres into Foot-tons.

T.-metres	0	1	2	3	4	5	6	7	8	9
	F.-tn.	F.-tn.	F.-tn.	F.-tn.	F.-tn.	F.-tn.	F.-tn.	F.-tn.	F.-tn.	F.-tn.
0	0.0000	3.2290	6.4581	9.6871	12.916	16.145	19.374	22.603	25.832	29.061
10	32.290	35.519	38.758	41.977	45.206	48.435	51.664	54.893	58.122	61.351
20	64.581	67.810	71.049	74.268	77.497	80.726	83.955	87.184	90.413	93.642
30	96.871	100.10	103.34	106.56	109.79	113.01	116.24	119.47	122.70	125.93
40	129.16	132.39	135.63	138.85	142.07	145.30	148.53	151.76	154.99	158.22
50	161.45	164.68	167.92	171.14	174.36	177.59	180.82	184.05	187.28	190.51
60	193.74	196.97	200.21	203.43	206.65	209.88	213.11	216.34	219.57	222.80
70	226.03	229.26	232.50	235.72	238.94	242.17	245.40	248.63	251.86	255.09
80	258.32	261.55	264.79	268.01	271.23	274.46	277.69	280.92	284.15	287.38
90	290.61	293.84	297.08	300.30	303.52	306.75	309.98	313.21	316.44	319.67
100	322.90	326.13	329.37	332.59	335.81	339.04	342.27	345.50	348.73	351.96

British Thermal Units into French Calories.

B. T. U.	0	1	2	3	4	5	6	7	8	9
	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.
0	0.0000	0.2520	0.5040	0.7560	1.0080	1.2600	1.5120	1.7640	2.0160	2.2680
10	2.5200	2.7720	3.0240	3.2760	3.5280	3.7800	4.0320	4.2840	4.5360	4.7880
20	5.0399	5.2919	5.5439	5.7959	6.0478	6.2999	6.5519	6.8039	7.0559	7.3079
30	7.5600	7.8120	8.0640	8.3160	8.5680	8.8200	9.0720	9.3240	9.5760	9.8280
40	10.080	10.332	10.584	10.836	11.088	11.340	11.592	11.844	12.096	12.348
50	12.600	12.852	13.104	13.356	13.608	13.860	14.112	14.364	14.616	14.868
60	15.120	15.372	15.624	15.876	16.128	16.380	16.632	16.884	17.136	17.388
70	17.640	17.892	18.144	18.396	18.648	18.900	19.152	19.404	19.656	19.908
80	20.160	20.412	20.664	20.916	21.168	21.420	21.672	21.924	22.176	22.428
90	22.680	22.932	23.184	23.436	23.688	23.940	24.192	24.444	24.696	24.948
100	25.200	25.452	25.704	25.956	26.208	26.460	26.712	26.964	27.216	27.468

French Calories into British Thermal Units.

Calories.	0	1	2	3	4	5	6	7	8	9
	T. U.	T. U.	T. U.	T. U.	T. U.	T. U.	T. U.	T. U.	T. U.	T. U.
0	0.0000	3.9683	7.9366	11.905	15.873	19.842	23.810	27.778	31.746	35.715
10	39.683	43.651	47.620	51.588	55.520	59.525	63.493	67.461	71.429	75.398
20	79.366	83.334	87.303	91.271	95.203	99.208	103.17	107.14	111.11	115.08
30	119.05	123.02	126.98	130.95	134.99	138.89	142.86	146.83	150.80	154.77
40	158.73	162.70	166.66	170.62	174.57	178.57	182.54	186.51	190.48	194.45
50	198.42	202.39	206.35	210.39	214.26	218.26	222.23	226.20	230.16	234.13
60	238.10	242.07	246.03	250.00	253.94	258.94	261.91	265.88	269.85	273.82
70	277.78	281.75	285.72	289.68	293.62	297.62	301.59	305.56	309.53	313.50
80	317.46	321.43	325.40	329.36	333.29	337.30	341.27	345.24	349.20	353.18
90	357.15	361.12	365.09	369.05	372.98	376.99	380.96	384.93	388.90	392.87
100	396.83	400.80	404.77	408.73	412.67	416.67	420.64	424.61	428.58	432.5[illegible]

Deg.	Min.	Sine.	Vers. Cos.	Cosecant.	Tang.	Co-tang.	Secant.	Vers. Sin.	Co-sine.	Min.	Deg.
0	0	.00000	1.0000	Infin.	.00000	Infin.	1.0000	.00000	1.0000		
	10	.00291	.99709	343.77	.00291	343.77	1.0000	.00000	.99999	50	90
	20	.00582	.99418	171.89	.00582	171.88	1.0000	.00002	.99998	40	
	30	.00873	.99127	114.59	.00873	114.59	1.0000	.00004	.99996	30	
	40	.01163	.98836	85.946	.01164	85.940	1.0001	.00007	.99993	20	
	50	.01454	.98546	68.757	.01454	68.750	1.0001	.00010	.99989	10	
1	0	.01745	.98255	57.299	.01745	57.290	1.0001	.00015	.99985		89
	10	.02036	.97964	49.114	.02036	49.104	1.0002	.00021	.99979	50	
	20	.02327	.97673	42.976	.02327	42.964	1.0003	.00027	.99973	40	
	30	.02618	.97382	38.201	.02618	38.188	1.0003	.00034	.99966	30	
	40	.02908	.97091	34.382	.02910	34.368	1.0004	.00042	.99958	20	
	50	.03199	.96801	31.257	.03201	31.241	1.0005	.00051	.99949	10	
2	0	.03490	.96510	28.654	.03492	28.636	1.0006	.00061	.99939		88
	10	.03781	.96219	26.450	.03783	26.432	1.0007	.00071	.99928	50	
	20	.04071	.95929	24.562	.04075	24.542	1.0008	.00083	.99917	40	
	30	.04362	.95638	22.925	.04366	22.904	1.0009	.00095	.99905	30	
	40	.04652	.95347	21.494	.04657	21.470	1.0011	.00108	.99892	20	
	50	.04943	.95057	20.230	.04949	20.205	1.0012	.00122	.99878	10	
3	0	.05234	.94766	19.107	.05241	19.081	1.0014	.00137	.99863		87
	10	.05524	.94476	18.103	.05532	18.075	1.0015	.00153	.99847	50	
	20	.05814	.94185	17.198	.05824	17.169	1.0017	.00169	.99831	40	
	30	.06105	.93895	16.380	.06116	16.350	1.0019	.00186	.99813	30	
	40	.06395	.93605	15.637	.06408	15.605	1.0020	.00205	.99795	20	
	50	.06685	.93314	14.958	.06700	14.924	1.0022	.00224	.99776	10	
4	0	.06976	.93024	14.335	.06993	14.301	1.0024	.00243	.99756		86
	10	.07266	.92734	13.763	.07285	13.727	1.0026	.00264	.99736	50	
	20	.07556	.92444	13.235	.07577	13.197	1.0029	.00286	.99714	40	
	30	.07846	.92154	12.745	.07870	12.706	1.0031	.00308	.99692	30	
	40	.08136	.91864	12.291	.08163	12.250	1.0033	.00331	.99668	20	
	50	.08426	.91574	11.868	.08456	11.826	1.0036	.00356	.99644	10	
5	0	.08715	.91284	11.474	.08749	11.430	1.0038	.00380	.99619		85
	10	.09005	.90995	11 104	.09042	11.059	1.0041	.00406	.99594	50	
	20	.09295	.90705	10.758	.09335	10.712	1.0043	.00433	.99567	40	
	30	.09584	.90415	10.433	.09629	10.385	1.0046	.00460	.99540	30	
	40	.09874	.90126	10.127	.09922	10.078	1 0049	.00489	.99511	20	
	50	.10163	.89836	9.8391	.10216	9.7882	1.0052	.00518	.99482	10	
6	0	.10453	.89547	9.5668	.10510	9.5144	1.0055	.00548	.99452		84
	10	.10742	.89258	9.3092	.10805	9.2553	1.0058	.00579	.99421	50	
	20	.11031	.88969	9.0651	.11099	9.0098	1.0061	.00110	.99390	40	
	30	.11320	.88680	8.8337	.11393	8.7769	1.0065	.00643	.99357	30	
	40	.11609	.88391	8.6138	.11688	8.5555	1.0068	.00676	.99324	20	
	50	.11898	.88102	8.4046	.11983	8.3449	1.0071	.00710	.99290	10	
7	0	.12187	.87813	8.2055	.12278	8.1443	1.0075	.00745	.99255		83
	10	.12476	.87524	8.0156	.12574	7.9530	1.0079	.00781	.99219	50	
	20	.12764	.87236	7.8344	.12869	7.7703	1.0082	.00818	.99182	40	
	30	.13053	.86947	7.6613	.13165	7.5957	1.0086	.00855	.99144	30	
	40	.13341	.86659	7.4957	.13461	7.4287	1.0090	.00894	.99106	20	
	50	.13629	.86371	7.3372	.13757	7.2687	1.0094	.00933	.99067	10	
8	0	.13917	.86083	7.1853	.14054	7.1154	1.0098	.00973	.99027		82
	10	.14205	.85795	7.0396	.14351	6 9682	1.0102	.01014	.98986	50	
	20	.14493	.85507	6.8998	.14648	6.8269	1.0107	.01056	.98944	40	
	30	.14781	.85219	6.7655	.14945	6.6911	1.0111	.01098	.98901	30	
	40	.15068	.84931	6.6363	.15243	6.5605	1.0115	.01142	.98858	20	
	50	.15356	.84644	6.5121	.15540	6.4348	1.0120	.01186	.98814	10	
9	0	.15643	.84356	6.3924	.15838	6.3137	1.0125	.01231	.98769		81
		Co-Sine.	Vers. Sin.	Secant	Co-tang.	Tangent.	Cosecant.	Vers Cos.	Sine.		

Deg.	Min.	Sine.	Vers. Cos.	Cosecant.	Tang.	Co-tang.	Se-cant.	Vers. Sin.	Co-sine.	Min.	Deg.
9	0	.15643	.84356	6.3924	.15838	6.3137	1.0125	.01231	.98769		81
	10	.15931	.84069	6.2772	.16137	6.1970	1.0129	.01277	.98723	50	
	20	.16218	.83782	6.1661	.16435	6.0844	1.0134	.01324	.98676	40	
	30	.16505	.83495	6.0588	.16734	5.9758	1.0139	.01371	.98628	30	
	40	.16791	.83208	5.9554	.17033	5.8708	1.0144	.01420	.98580	20	
	50	.17078	.82922	5.8554	.17333	5.7694	1.0149	.01469	.98531	10	
10	0	.17365	.82635	5.7588	.17633	5.6713	1.0154	.01519	.98481		80
	10	.17651	.82349	5.6653	.17933	5.5764	1.0159	.01570	.98430	50	
	20	.17937	.82062	5.5749	.18233	5.4845	1.0165	.01622	.98378	40	
	30	.18223	.81776	5.4874	.18534	5.3955	1.0170	.01674	.98325	30	
	40	.18509	.81490	5.4026	.18835	5.3093	1.0176	.01728	.98272	20	
	50	.18795	.81205	5.3205	.19136	5.2257	1.0181	.01782	.98218	10	
11	0	.19081	.80919	5.2408	.19438	5.1445	1.0187	.01837	.98163		79
	10	.19366	.80634	5.1636	.19740	5.0658	1.0193	.01893	.98107	50	
	20	.19652	.80348	5.0886	.20042	4.9894	1.0199	.01950	.98050	40	
	30	.19937	.80063	5.0158	.20345	4.9151	1.0205	.02007	.97992	30	
	40	.20222	.79778	4.9452	.20648	4.8430	1.0211	.02066	.97934	20	
	50	.20506	.79493	4.8765	.20952	4.7728	1.0217	.02125	.97875	10	
12	0	.20791	.79209	4.8097	.21256	4.7046	1.0223	.02185	.97815		78
	10	.21076	.78924	4.7448	.21560	4.6382	1.0230	.02246	.97754	50	
	20	.21360	.78640	4.6817	.21864	4.5736	1.0236	.02308	.97692	40	
	30	.21644	.78356	4.6202	.22169	4.5107	1.0243	.02370	.97630	30	
	40	.21928	.78072	4.5604	.22475	4.4494	1.0249	.02434	.97566	20	
	50	.22211	.77788	4.5021	.22781	4.3897	1.0256	.02498	.97502	10	
13	0	.22495	.77505	4.4454	.23087	4.3315	1.0263	.02563	.97437		77
	10	.22778	.77221	4.3901	.23393	4.2747	1.0270	.02629	.97371	50	
	20	.23061	.76938	4.3362	.23700	4.2193	1.0277	.02695	.97304	40	
	30	.23344	.76655	4.2836	.24008	4.1653	1.0284	.02763	.97237	30	
	40	.23627	.76373	4.2324	.24316	4.1127	1.0291	.02831	.97169	20	
	50	.23910	.76090	4.1824	.24624	4.0611	1.0299	.02900	.97099	10	
14	0	.24192	.75808	4.1336	.24933	4.0108	1.0306	.02970	.97029		76
	10	.24474	.75526	4.0859	.25242	3.9616	1.0314	.03041	.96959	50	
	20	.24756	.75244	4.0394	.25552	3.9136	1.0321	.03113	.96887	40	
	30	.25038	.74962	3.9939	.25862	3.8667	1.0329	.03185	.96815	30	
	40	.25319	.74680	3.9495	.26172	3.8208	1.0337	.03258	.96741	20	
	50	.25601	.74399	3.9061	.26483	3.7759	1.0345	.03332	.96667	10	
15	0	.25882	.74118	3.8637	.26795	3.7320	1.0353	.03407	.96592		75
	10	.26163	.73837	3.8222	.27107	3.6891	1.0361	.03483	.96517	50	
	20	.26443	.73556	3.7816	.27419	3.6470	1.0369	.03560	.96440	40	
	30	.26724	.73276	3.7420	.27732	3.6059	1.0377	.03637	.96363	30	
	40	.27004	.72996	3.7031	.28046	3.5656	1.0386	.03715	.96285	20	
	50	.27284	.72716	3.6651	.28360	3.5261	1.0394	.03794	.96206	10	
16	0	.27564	.72436	3.6279	.28674	3.4874	1.0403	.03874	.96126		74
	10	.27843	.72157	3.5915	.28990	3.4495	1.0412	.03954	.96045	50	
	20	.28122	.71877	3.5559	.29305	3.4124	1.0420	.04036	.95964	40	
	30	.28401	.71608	3.5209	.29621	3.3759	1.0429	.04118	.95882	30	
	40	.28680	.71320	3.4867	.29938	3.3402	1.0438	.04201	.95799	20	
	50	.28959	.71041	3.4532	.30255	3.3052	1.0448	.04285	.95715	10	
17	0	.29237	.70763	3.4203	.30573	3.2708	1.0457	.04369	.95630		73
	10	.29515	.70485	3.3881	.30891	3.2371	1.0466	.04455	.95545	50	
	20	.29793	.70207	3.3565	.31210	3.2041	1.0476	.04541	.95459	40	
	30	.30070	.69929	3.3255	.31530	3.1716	1.0485	.04628	.95372	30	
	40	.30348	.69652	3.2951	.31850	3.1397	1.0495	.04716	.95284	20	
	50	.30625	.69375	3.2653	.32171	3.1084	1.0505	.04805	.95195	10	
18	0	.30902	.69098	3.2361	.32492	3.0777	1.0515	.04894	.95106		72
		Co-sine.	Vers. Sin.	Se-cant.	Co-tang.	Tan-gent.	Cose-cant.	Vers. Cos.	Sine.		

Deg.	Min.	Sine.	Vers. Cos.	Cosecant.	Tang.	Co-tang.	Se-cant.	Vers. Sin.	Co-sine.	Min.	Deg.
18	0	.30902	.69098	3.2361	.32492	3.0777	1.0515	.04894	.95106		72
	10	.31178	.68822	3.2074	.32814	3.0475	1.0525	.04985	.95015	50	
	20	.31454	.68545	3.1792	.33136	3.0178	1.0535	.05076	.94924	40	
	30	.31730	.68269	3.1515	.33459	2.9887	1.0545	.05168	.94832	30	
	40	.32006	.67994	3.1244	.33783	2.9600	1.0555	.05260	.94740	20	
	50	.32282	.67718	3.0977	.34108	2.9319	1.0566	.05354	.94646	10	
19	0	.32557	.67443	3.0715	.34433	2.9042	1.0576	.05448	.94552		71
	10	.32832	.67168	3.0458	.34758	2.8770	1.0587	.05543	.94457	50	
	20	.33106	.66894	3.0206	.35085	2.8502	1.0598	.05639	.94361	40	
	30	.33381	.66619	2.9957	.35412	2.8239	1.0608	.05736	.94264	30	
	40	.33655	.66345	2.9713	.35739	2.7980	1.0619	.05833	.94167	20	
	50	.33928	.66071	2.9474	.36068	2.7725	1.0630	.05932	.94068	10	
20	0	.34202	.65798	2.9238	.36397	2.7475	1.0642	.06031	.93969		70
	10	.34475	.65525	2.9006	.36727	2.7228	1.0653	.06131	.93869	50	
	20	.34748	.65252	2.8778	.37057	2.6985	1.0664	.06231	.93769	40	
	30	.35021	.64979	2.8554	.37388	2.6746	1.0676	.06333	.93667	30	
	40	.35293	.64707	2.8334	.37720	2.6511	1.0688	.06435	.93565	20	
	50	.35565	.64435	2.8117	.38053	2.6279	1.0699	.06538	.93462	10	
21	0	.35837	.64163	2.7904	.38386	2.6051	1.0711	.06642	.93358		69
	10	.36108	.63892	2.7694	.38720	2.5826	1.0723	.06747	.93253	50	
	20	.36379	.63621	2.7488	.39055	2.5605	1.0736	.06852	.93148	40	
	30	.36650	.63350	2.7285	.39391	2.5386	1.0748	.06958	.93042	30	
	40	.36921	.63079	2.7085	.39727	2.5171	1.0760	.07065	.92935	20	
	50	.37191	.62809	2.6888	.40065	2.4960	1.0773	.07173	.92827	10	
22	0	.37461	.62539	2.6695	.40403	2.4751	1.0785	.07282	.92718		68
	10	.37730	.62270	2.6504	.40741	2.4545	1.0798	.07391	.92609	50	
	20	.37999	.62000	2.6316	.41081	2.4342	1.0811	.07501	.92499	40	
	30	.38268	.61732	2.6131	.41421	2.4142	1.0824	.07612	.92388	30	
	40	.38537	.61463	2.5949	.41762	2.3945	1.0837	.07724	.92276	20	
	50	·38805	.61195	2.5770	.42105	2.3750	1.0850	.07836	.92164	10	
23	0	.39073	.60927	2.5593	.42447	2.3558	1.0864	.07949	.92050		67
	10	.39341	.60659	2.5419	.42791	2.3369	1.0877	.08063	.91936	50	
	20	.39608	.60392	2.5247	.43136	2.3183	1.0891	.08178	.91822	40	
	30	.39875	.60125	2.5078	.43481	2.2998	1.0904	.08294	.91706	30	
	40	.40141	.59858	2.4912	.43827	2.2817	1.0918	.08410	.91590	20	
	50	.40408	.59592	2.4748	.44175	2.2637	1.0932	.08527	.91472	10	
24	0	.40674	.59326	2.4586	.44523	2.2460	1.0946	.08645	.91354		66
	10	.40939	.59061	2.4426	.44872	2.2286	1.0961	.08764	.91236	50	
	20	.41204	.58795	2.4269	.45222	2.2113	1.0975	.08884	.91116	40	
	30	.41469	.58531	2.4114	.45573	2.1943	1.0989	.09004	.90996	30	
	40	.41734	.58266	2.3961	.45924	2.1775	1.1004	.09125	.90875	20	
	50	.41998	.58002	2.3811	.46277	2.1609	1.1019	.09247	.90753	10	
25	0	.42262	.57738	2.3662	.46631	2.1445	1.1034	.09369	.90631		65
	10	.42525	.57475	2.3515	.46985	2.1283	1.1049	.09492	.90507	50	
	20	.42788	.57212	2.3371	.47341	2.1123	1.1064	.09617	.90383	40	
	30	.43051	.56949	2.3228	.47697	2.0965	1.1079	.09741	.90258	30	
	40	.43313	.56686	2.3087	.48055	2.0809	1.1095	.09867	.90133	20	
	50	.43575	·56424	2.2949	.48414	2.0655	1.1110	.09993	.90006	10	
26	0	.43837	.56163	2.2812	.48773	2.0503	1.1126	.10121	.89879		64
	10	.44098	.55902	2.2676	.49134	2.0352	1.1142	.10248	.89751	50	
	20	.44359	.55641	2.2543	.49495	2.0204	1.1158	.10377	.89623	40	
	30	.44620	.55380	2.2411	.49858	2.0057	1.1174	.10506	.89493	30	
	40	.44880	.55120	2.2282	.50222	1.9912	1.1190	.10637	.89363	20	
	50	.45140	.54860	2.2153	.50587	1.9768	1.1207	.10768	.89232	10	
27		.45399	.54601	2.2027	.50952	1.9626	1.1223	.10899	.89101		63
		Co-sine.	Vers. Sin.	Se-cant.	Co-tang.	Tan-gent.	Cose-cant.	Vers. Cos.	Sine.		

Deg.	Min.	Sine.	Vers. Cos.	Cosecant.	Tang.	Co. Tang.	Secant.	Vers. Sin.	Co-sine.	Min.	Deg.
27	0	.45399	.54601	2.2027	.50952	1.9626	1.1223	.10899	.89101		63
	10	.45658	.54342	2.1902	.51319	1.9486	1.1240	.11032	.88968	50	
	20	.45917	.54083	2.1778	.51687	1.9347	1.1257	.11165	.88835	40	
	30	.46175	.53825	2.1657	.52057	1.9210	1.1274	.11299	.88701	30	
	40	.46433	.53567	2.1536	.52427	1.9074	1.1291	.11434	.88566	20	
	50	.46690	.53310	2.1418	.52798	1.8940	1.1308	.11569	.88431	10	
28	0	.46947	.53053	2.1300	.53171	1.8807	1.1326	.11705	.88295		62
	10	.47204	.52796	2.1185	.53545	1.8676	1.1343	.11842	.88158	50	
	20	.47460	.52540	2.1070	.53919	1.8546	1.1361	.11980	.88020	40	
	30	.47716	.52284	2.0957	.54295	1.8418	1.1379	.12118	.87882	30	
	40	.47971	.52029	2.0846	.54673	1.8291	1.1397	.12257	.87742	20	
	50	.48226	.51774	2.0735	.55051	1.8165	1.1415	.12397	.87603	10	
29	0	.48481	.51519	2.0627	.55431	1.8040	1.1433	.12538	.87462		61
	10	.48735	.51265	2.0519	.55812	1.7917	1.1452	.12679	.87320	50	
	20	.48989	.51011	2.0413	.56194	1.7795	1.1471	.12821	.87178	40	
	30	.49242	.50758	2.0308	.56577	1.7675	1.1489	.12964	.87035	30	
	40	.49495	.50505	2.0204	.56962	1.7555	1.1508	.13108	.86892	20	
	50	.49748	.50252	2.0101	.57348	1.7437	1.1528	.13252	.86748	10	
30	0	.50000	.50000	2.0000	.57735	1.7320	1.1547	.13397	.86602		60
	10	.50252	.49748	1.9900	.58123	1.7205	1.1566	.13543	.86457	50	
	20	.50503	.49497	1.9801	.58513	1.7090	1.1586	.13690	.86310	40	
	30	.50754	.49246	1.9703	.58904	1.6977	1.1606	.13837	.86163	30	
	40	.51004	.48996	1.9606	.59297	1.6864	1.1626	.13985	.86015	20	
	50	.51254	.48746	1.9510	.59691	1.6753	1.1646	.14134	.85866	10	
31	0	.51504	.48496	1.9416	.60086	1.6643	1.1666	.14283	.85717		59
	10	.51753	.48247	1.9322	.60483	1.6534	1.1687	.14433	.85566	50	
	20	.52002	.47998	1.9230	.60881	1.6425	1.1707	.14584	.85416	40	
	30	.52250	.47750	1.9139	.61280	1.6318	1.1728	.14736	.85264	30	
	40	.52498	.47502	1.9048	.61681	1.6212	1.1749	.14888	.85112	20	
	50	.52745	.47255	1.8959	.62083	1.6107	1.1770	.15041	.84959	10	
32	0	.52992	.47008	1.8871	.62487	1.6003	1.1792	.15195	.84805		58
	10	.53238	.46762	1.8783	.62892	1.5900	1.1813	.15350	.84650	50	
	20	.53484	.46516	1.8697	.63299	1.5798	1.1835	.15505	.84495	40	
	30	.53730	.46270	1.8611	.63707	1.5697	1.1857	.15661	.84339	30	
	40	.53975	.46025	1.8527	.64117	1.5596	1.1879	.15817	.84182	20	
	50	.54220	.45780	1.8443	.64528	1.5497	1.1901	.15975	.84025	10	
33	0	.54464	.45536	1.8361	.64941	1.5399	1.1924	.16133	.83867		57
	10	.54708	.45292	1.8279	.65355	1.5301	1.1946	.16292	.83708	50	
	20	.54951	.45049	1.8198	.65771	1.5204	1.1969	.16451	.83549	40	
	30	.55194	.44806	1.8118	.66188	1.5108	1.1992	.16611	.83388	30	
	40	.55436	.44564	1.8039	.66608	1.5013	1.2015	.16772	.83228	20	
	50	.55678	.44322	1.7960	.67028	1.4919	1.2039	.16934	.83066	10	
34	0	.55919	.44081	1.7883	.67451	1.4826	1.2062	.17096	.82904		56
	10	.56160	.43840	1.7806	.67875	1.4733	1.2086	.17259	.82741	50	
	20	.56401	.43599	1.7730	.68301	1.4641	1.2110	.17423	.82577	40	
	30	.56641	.43359	1.7655	.68728	1.4550	1.2134	.17587	.82413	30	
	40	.56880	.43120	1.7581	.69157	1.4460	1.2158	.17752	.82247	20	
	50	.57119	.42881	1.7507	.69588	1.4370	1.2183	.17918	.82082	10	
35	0	.57358	.42642	1.7434	.70021	1.4281	1.2208	.18085	.81915		55
	10	.57596	.42404	1.7362	.70455	1.4193	1.2233	.18252	.81748	50	
	20	.57833	.42167	1.7291	.70891	1.4106	1.2258	.18420	.81580	40	
	30	.58070	.41930	1.7220	.71329	1.4019	1.2283	.18588	.81411	30	
	40	.58307	.41693	1.7151	.71769	1.3933	1.2309	.18758	.81242	20	
	50	.58543	.41457	1.7081	.72211	1.3848	1.2335	.18928	.81072	10	
36	0	.58778	.41221	1.7013	.72654	1.3764	1.2361	.19098	.80902		54
		Co-sine.	Vers. Sin.	Secant.	Co-tang.	Tangent.	Cosecant.	Vers. Cos.	Sine.		

Deg.	Min.	Sine.	Vers. Cos.	Cosecant.	Tang.	Co-tang.	Secant.	Vers. Sin.	Co-sine.	Min.	Deg.
36	0	.58778	.41221	1.7013	.72654	1.3764	1.2361	.19098	.80902		**54**
	10	.59014	.40986	1.6945	.73100	1.3680	1.2387	.19270	.80730	50	
	20	.59248	.40752	1.6878	.73547	1.3597	1.2413	.19442	.80558	40	
	30	.59482	.40518	1.6812	.73996	1.3514	1.2440	.19614	.80386	30	
	40	.59716	.40284	1.6746	.74447	1.3432	1.2467	.19788	.80212	20	
	50	.59949	.40051	1.6681	.74900	1.3351	1.2494	.19962	.80038	10	
37	0	.60181	.39818	1.6616	.75355	1.3270	1.2521	.20136	.79863		**53**
	10	.60413	.39586	1.6552	.75812	1.3190	1.2549	.20312	.79688	50	
	20	.60645	.39355	1.6489	.76271	1.3111	1.2577	.20488	.79512	40	
	30	.60876	.39124	1.6427	.76733	1.3032	1.2605	.20665	.79335	30	
	40	.61107	.38893	1.6365	.77196	1.2954	1.2633	.20842	.79158	20	
	50	.61337	.38663	1.6303	.77661	1.2876	1.2661	.21020	.78980	10	
38	0	.61566	.38434	1.6243	.78128	1.2799	1.2690	.21199	.78801		**52**
	10	.61795	.38205	1.6182	.78598	1.2723	1.2719	.21378	.78622	50	
	20	.62023	.37976	1.6123	.79070	1.2647	1.2748	.21558	.78441	40	
	30	.62251	.37748	1.6064	.79543	1.2572	1.2778	.21739	.78261	30	
	40	.62479	.37521	1.6005	.80020	1.2497	1.2807	.21921	.78079	20	
	50	.62706	.37294	1.5947	.80498	1.2423	1.2837	.22103	.77897	10	
39	0	.62932	.37068	1.5890	.80978	1.2349	1.2867	.22285	.77715		**51**
	10	.63158	.36842	1.5833	.81461	1.2276	1.2898	.22469	.77531	50	
	20	.63383	.36617	1.5777	.81946	1.2203	1.2929	.22653	.77347	40	
	30	.63608	.36392	1.5721	.82434	1.2131	1.2960	.22837	.77162	30	
	40	.63832	.36168	1.5666	.82923	1.2059	1.2991	.23023	.76977	20	
	50	.64056	.35944	1.5611	.83415	1.1988	1.3022	.23209	.76791	10	
40	0	.64279	.35721	1.5557	.83910	1.1917	1.3054	.23395	.76604		**50**
	10	.64501	.35499	1.5503	.84407	1.1847	1.3086	.23583	.76417	50	
	20	.64723	.35277	1.5450	.84906	1.1778	1.3118	.23771	.76229	40	
	30	.64945	.35055	1.5398	.85408	1.1708	1.3151	.23959	.76041	30	
	40	.65166	.34834	1.5345	.85912	1.1640	1.3184	.24149	.75851	20	
	50	.65386	.34614	1.5294	.86419	1.1571	1.3217	.24338	.75661	10	
41	0	.65606	.34394	1.5242	.86929	1.1504	1.3250	.24529	.75471		**49**
	10	.65825	.34175	1.5192	.87441	1.1436	1.3284	.24720	.75280	50	
	20	.66044	.33956	1.5141	.87955	1.1369	1.3318	.24912	.75088	40	
	30	.66262	.33738	1.5092	.88472	1.1303	1.3352	.25104	.74895	30	
	40	.66479	.33520	1.5042	.88992	1.1237	1.3386	.25297	.74702	20	
	50	.66697	.33303	1.4993	.89515	1.1171	1.3421	.25491	.74509	10	
42	0	.66913	.33087	1.4945	.90040	1.1106	1.3456	.25685	.74314		**48**
	10	.67129	.32871	1.4897	.90568	1.1041	1.3492	.25880	.74119	50	
	20	.67344	.32656	1.4849	.91099	1.0977	1.3527	.26076	.73924	40	
	30	.67559	.32441	1.4802	.91633	1.0913	1.3563	.26272	.73728	30	
	40	.67773	.32227	1.4755	.92170	1.0849	1.3600	.26469	.73531	20	
	50	.67987	.32013	1.4709	.92709	1.0786	1.3636	.26666	.73333	10	
43	0	.68200	.31800	1.4663	.93251	1.0724	1.3673	.26865	.73135		**47**
	10	.68412	.31588	1.4617	.93797	1.0661	1.3710	.27063	.72937	50	
	20	.68624	.31376	1.4572	.94345	1.0599	1.3748	.27263	.72737	40	
	30	.68835	.31164	1.4527	.94896	1.0538	1.3786	.27462	.72537	30	
	40	.69046	.30954	1.4483	.95451	1.0476	1.3824	.27663	.72337	20	
	50	.69256	.30744	1.4439	.96008	1.0416	1.3863	.27864	.72136	10	
44	0	.69466	.30534	1.4395	.96569	1.0355	1.3902	.28066	.71934		**46**
	10	.69675	.30325	1.4352	.97133	1.0295	1.3941	.28268	.71732	50	
	20	.69883	.30117	1.4310	.97699	1.0235	1.3980	.28471	.71529	40	
	30	.70091	.29909	1.4267	.98270	1.0176	1.4020	.28675	.71325	30	
	40	.70298	.29702	1.4225	.98843	1.0117	1.4060	.28879	.71121	20	
	50	.70505	.29495	1.4183	.99420	1.0058	1.4101	.29084	.70916	10	
45	0	.70711	.29289	1.4142	1.0000	1.0000	1.4142	.29289	.70711		**45**
		Co-sine.	Vers. Sin.	Secant.	Co-tang.	Tan-gent.	Cosecant.	Vers. Cos.	Sine.		

CIRCUMFERENCE AND AREA OF CIRCLES.

The Circle.

Notation.

d = diameter of the circle.	c = chord of a segment, length of.
r = radius of the circle.	h = height of a segment.
p = periphery or circumference.	s = side of a regular polygon.
a = area of a circle or part thereof.	v = centre angle.
b = length of a circle-arc.	w = polygon angle.

All measures must be expressed in terms of the same unit.

Formulas for the Circle.

Periphery or Circumference.	*Diameter and Radius.*	*Area of the Circle.*
$p = \pi d = 3.14d.$	$d = \frac{p}{\pi} = \frac{p}{3.14}.$	$a = \frac{\pi d^2}{4} = 0.7854d^2.$
$p = 2\pi r = 6.28r.$	$r = \frac{p}{2\pi} = \frac{p}{6.28}.$	$a = \pi r^2 = 3.14r^2.$
$p = 2\sqrt{\pi a} = 3.54\sqrt{a}.$	$d = 2\sqrt{\frac{a}{\pi}} = 1.128\sqrt{a}.$	$a = \frac{p^2}{4\pi} = \frac{p^2}{12.56}.$
$p = \frac{2a}{r} = \frac{4a}{d}.$	$r = \sqrt{\frac{a}{\pi}} = 0.564\sqrt{a}.$	$a = \frac{pr}{2} = \frac{pd}{4}.$

$$\pi = 3.141\,592\,653\,589\,793\,238\,462\,643\,383\,279\,502\,884\,197\,169\,399$$

$2\pi = 6.283\,185$	$\frac{1}{4}\pi = 0.785\,398$	$\frac{1}{\pi} = 0.318\,310$	$\frac{360}{\pi} = 114.5915$
$3\pi = 9.424\,778$	$\frac{1}{3}\pi = 1.047\,197$	$\frac{2}{\pi} = 0.636\,619$	$\pi^2 = 9.869\,650$
$4\pi = 12.566\,370$	$\frac{1}{2}\pi = 1.570\,796$	$\frac{3}{\pi} = 0.954\,929$	$\sqrt{\pi} = 1.772\,453$
$5\pi = 15.707\,963$	$\frac{1}{8}\pi = 0.392\,699$	$\frac{4}{\pi} = 1.273\,239$	$\sqrt{\frac{1}{\pi}} = 0.564\,189$
$6\pi = 18.849\,556$	$\frac{1}{6}\pi = 0.523\,599$	$\frac{6}{\pi} = 1.909\,859$	$\sqrt{\frac{\pi}{2}} = 1.253\,314$
$7\pi = 21.991\,148$	$\frac{1}{12}\pi = 0.261\,799$	$\frac{8}{\pi} = 2.546\,478$	$\sqrt{\frac{2}{\pi}} = 0.797\,884$
$8\pi = 25.132\,741$	$\frac{2}{3}\pi = 2.094\,394$	$\frac{12}{\pi} = 3.819\,718$	
$9\pi = 28.274\,334$	$\frac{1}{360}\pi = 0.008\,726$		

Log. $\pi = 0.497\,149\,872\,69413$

Diameter.	Circum.	Area.	Diameter.	Circum.	Area.	Diameter.	Circum.	Area.
1	3.1416	0.7854	51	160.22	2042.8	101	317.30	8011.9
2	6.2832	3.1416	52	163.36	2123.7	102	320.44	8171.3
3	9.4248	7.0686	53	166.50	2206.2	103	323.58	8332.3
4	12.566	12.5664	54	169.65	2290.2	104	326.73	8494.9
5	15.708	19.6350	55	172.79	2375.8	105	329.87	8659.0
6	18.850	28.2743	56	175.93	2463.0	106	333.01	8824.7
7	21.991	38.4845	57	179.07	2551.8	107	336.15	8992.0
8	25.133	50.2655	58	182.21	2642.1	108	339.29	9160.9
9	28.274	63.6173	59	185.35	2734.0	109	342.43	9331.3
10	31.416	78.54	60	188.50	2827.4	110	345.58	9503.3
11	34.558	95.03	61	191.64	2922.5	111	348.72	9676.9
12	37.699	113.10	62	194.78	3019.1	112	351.86	9852.0
13	40.841	132.73	63	197.92	3117.2	113	355.00	10028.8
14	43.982	153.94	64	201.06	3217.0	114	358.14	10207.0
15	47.124	176.71	65	204.20	3318.3	115	361.28	10386.9
16	50.265	201.06	66	207.35	3421.2	116	364.42	10568.3
17	53.407	226.98	67	210.49	3525.7	117	367.57	10751.3
18	56.549	254.47	68	213.63	3631.7	118	370.71	10935.9
19	59.690	283.53	69	216.77	3739.3	119	373.85	11122.0
20	62.832	314.16	70	219.91	3848.5	120	376.99	11310
21	65.973	346.36	71	223.05	3959.2	121	380.13	11499
22	69.115	380.13	72	226.19	4071.5	122	383.27	11690
23	72.257	415.48	73	229.34	4185.4	123	386.42	11882
24	75.398	452.39	74	232.48	4300.8	124	389.56	12076
25	78.540	490.87	75	235.62	4417.9	125	392.70	12272
26	81.681	530.93	76	238.76	4536.5	126	395.84	12469
27	84.823	572.56	77	241.90	4656.6	127	398.98	12668
28	87.965	615.75	78	245.04	4778.4	128	402.12	12868
29	91.106	660.52	79	248.19	4901.7	129	405.27	13070
30	94.248	706.86	80	251.33	5026.6	130	408.41	13273
31	97.389	754.77	81	254.47	5153.0	131	411.55	13478
32	100.53	804.25	82	257.61	5281.0	132	414.69	13685
33	103.67	855.30	83	260.75	5410.6	133	417.83	13893
34	106.81	907.92	84	263.89	5541.8	134	420.97	14103
35	109.96	962.11	85	267.04	5674.5	135	424.12	14314
36	113.10	1017.88	86	270.18	5808.8	136	427.26	14527
37	116.24	1075.21	87	273.32	5944.7	137	430.40	14741
38	119.38	1134.11	88	276.46	6082.1	138	433.54	14957
39	122.52	1194.59	89	279.60	6221.1	139	436.68	15175
40	125.66	1256.63	90	282.74	6361.7	140	439.82	15394
41	128.81	1320.25	91	285.88	6503.9	141	442.96	15615
42	131.95	1385.44	92	289.03	6647.6	142	446.11	15837
43	135.09	1452.20	93	292.17	6792.9	143	449.25	16061
44	138.23	1520.52	94	295.31	6939.8	144	452.39	16286
45	141.37	1590.43	95	298.45	7088.2	145	455.53	16513
46	144.51	1661.90	96	301.59	7238.2	146	458.67	16742
47	147.65	1734.94	97	304.73	7389.8	147	461.81	16972
48	150.80	1809.55	98	307.88	7543.0	148	464.96	17203
49	153.94	1885.74	99	311.02	7697.7	149	468.10	17437
50	157.08	1963.50	100	314.16	7854.0	150	471.24	17671

Diameter.	Circum.	Area.	Diameter.	Circum.	Area.	Diameter.	Circum.	Area.
151	474.38	17908	201	631.46	31731	251	788.54	49481
152	477.52	18146	202	634.60	32047	252	791.68	49876
153	480.66	18385	203	637.74	32365	253	794.82	50273
154	483.81	18627	204	640.89	32685	254	797.96	50671
155	486.95	18869	205	644.03	33006	255	801.11	51071
156	490.09	19113	206	647.17	33329	256	804.25	51472
157	493.23	19359	207	650.31	33654	257	807.39	51875
158	496.37	19607	208	653.45	33979	258	810.53	52279
159	499.51	19856	209	656.59	34307	259	813.67	52685
160	502.65	20106	210	659.73	34636	260	816.81	53093
161	505.80	20358	211	662.88	34967	261	819.96	53502
162	508.94	20612	212	666.02	35299	262	823.10	53913
163	512.08	20867	213	669.16	35633	263	826.24	54325
164	515.22	21124	214	672.30	35968	264	829.38	54739
165	518.36	21382	215	675.44	36305	265	832.52	55155
166	521.50	21642	216	678.58	36644	266	835.66	55572
167	524.65	21904	217	681.73	36984	267	838.81	55990
168	527.79	22167	218	684.87	37325	268	841.95	56410
169	530.93	22432	219	688.01	37668	269	845.09	56832
170	534.07	22698	220	691.15	38013	270	848.23	57256
171	537.21	22966	221	694.29	38360	271	851.37	57680
172	540.35	23235	222	697.43	38708	272	854.51	58107
173	543.50	23506	223	700.58	39057	273	857.66	58535
174	546.64	23779	224	703.72	39408	274	860.80	58965
175	549.78	24053	225	706.86	39761	275	863.94	59396
176	552.92	24328	226	710.00	40115	276	867.08	59828
177	556.06	24606	227	713.14	40471	277	870.22	60263
178	559.20	24885	228	716.28	40828	278	873.36	60699
179	562.35	25165	229	719.42	41187	279	876.50	61136
180	565.49	25447	230	722.57	41548	280	879.65	61575
181	568.63	25730	231	725.71	41910	281	882.79	62016
182	571.77	26016	232	728.85	42273	282	885.93	62458
183	574.91	26302	233	731.99	42638	283	889.07	62902
184	578.05	26590	234	735.13	43005	284	892.21	63347
185	581.19	26880	235	738.27	43374	285	895.35	63794
186	584.34	27172	236	741.42	43744	286	898.50	64242
187	587.48	27465	237	744.56	44115	287	901.64	64692
188	590.62	27759	238	747.70	44488	288	904.78	65144
189	593.76	28055	239	750.84	44863	289	907.92	65597
190	596.90	28353	240	753.98	45239	290	911.06	66052
191	600.04	28652	241	757.12	45617	291	914.20	66508
192	603.19	28953	242	760.27	45996	292	917.35	66966
193	606.33	29255	243	763.41	46377	293	920.49	67426
194	609.47	29559	244	766.55	46759	294	923.63	67887
195	612.61	29865	245	769.69	47144	295	926.77	68349
196	615.75	30172	246	772.83	47529	296	929.91	68813
197	618.89	30481	247	775.97	47916	297	933.05	69279
198	622.04	30791	248	779.12	48305	298	936.19	69747
199	625.18	31103	249	782.26	48695	299	939.34	70215
200	628.32	31416	250	785.40	49087	300	942.48	7068[illegible]

Diameter.	Circum.	Area.	Diameter.	Circum.	Area.	Diameter.	Circum.	Area.
301	945.62	71158	351	1102.70	96 762	401	1259.78	126 293
302	948.76	[redacted]	352	1105.84	97 314	402	1262.92	126 923
303	951.90	72107	353	1108.98	97 868	403	1266.06	127 556
304	955.04	72583	354	1112.12	98 423	404	1269.20	128 190
305	958.19	73062	355	1115.27	98 980	405	1272.35	128 825
306	961.33	73542	356	1118.41	99 538	406	1275.49	129 462
307	964.47	74023	357	1121.55	100 098	407	1278.63	130 100
308	967.61	74506	358	1124.69	100 660	408	1281.77	130 741
309	970.75	74991	359	1127.83	101 223	409	1284.91	131 382
310	973.89	75477	360	1130.97	101 788	410	1288.05	132 025
311	977.04	75964	[redacted]	1134.11	102 354	411	1291.19	132 670
312	980.18	76454	362	1137.26	102 922	412	1294.34	133 317
313	983.32	76945	363	1140.40	103 491	413	1297.48	133 965
314	986.46	77437	364	1143.54	104 062	414	1300.62	134 614
315	989.60	77931	365	1146.68	104 635	415	1303.76	135 265
316	992.74	78427	366	1149.82	105 209	416	1306.90	135 918
317	995.88	78924	367	1152.96	105 785	417	1310.04	136 572
318	999.03	79423	368	1156.11	106 362	418	1313.19	[redacted]
319	1002.17	79923	369	1159.25	106 941	419	1316.33	137 885
320	1005.31	80425	370	1162.39	107 521	420	1319.47	138 544
321	1008.45	80928	371	1165.53	108 103	421	1322.61	139 205
322	1011.59	81433	372	1168.67	108 687	422	1325.75	139 867
323	1014.73	81940	373	1171.81	109 272	423	1328.89	140 531
324	1017.88	82448	374	1174.96	109 858	424	1332.04	141 196
325	1021.02	82958	375	1178.10	110 447	425	1335.18	141 863
326	1024.16	83469	376	1181.24	111 036	426	1338.32	142 531
327	1027.30	83982	377	1184.38	111 628	427	1341.46	143 201
328	1030.44	84496	378	1187.52	112 221	428	1344.60	143 872
329	1033.58	85012	379	1190.66	112 815	429	1347.74	144 545
330	1036.73	85530	380	1193.81	113 411	430	1350.88	145 220
331	1039.87	86049	381	1196.95	114 009	431	1354.03	145 896
332	1043.01	86570	382	1200.09	114 608	432	1357.17	146 574
333	1046.15	87092	383	1203.23	115 209	433	1360.31	147 254
334	1049.29	87616	384	1206.37	115 812	434	1363.45	147 934
335	1052.43	88141	385	1209.51	116 416	435	1366.59	148 617
336	1055.58	88668	386	1212.65	117 021	436	1369.73	149 301
337	1058.72	89197	387	1215.80	117 628	437	1372.88	149 987
338	1061.86	89727	388	1218.94	118 237	438	1376.02	150 674
339	1065.00	90259	389	1222.08	118 847	439	1379.16	151 363
340	1068.14	90792	390	1225.22	119 459	440	1382.30	152 053
341	1071.28	91327	391	1228.36	120 072	441	1385.44	152 745
342	1074.42	91863	392	1231.50	120 687	442	1388.58	153 439
343	1077.57	92401	393	1234.65	121 304	443	1391.73	154 134
344	1080.71	92941	394	1237.79	121 922	444	1394.87	154 830
345	1083.85	93482	395	1240.93	122 542	445	1398.01	155 528
346	1086.99	94025	396	1244.07	123 163	446	1401.15	156 228
347	1090.13	94569	397	1247.21	123 786	447	1404.29	156 930
348	1093.27	95115	398	1250.35	124 410	448	1407.43	157 633
349	1096.42	95662	399	1253.50	125 036	449	1410.58	158 337
350	1099.56	96211	400	1256.64	125 664	450	1413.72	159 043

Diameter.	Circum.	Area.	Diameter.	Circum.	Area.	Diameter.	Circum.	Area.
451	1416.86	159 751	501	1573.94	197 136	551	1731.02	238 448
452	1420.00	160 460	502	1577.08	197 923	552	1734.16	239 314
453	1423.14	161 171	503	1580.22	198 713	553	1737.30	240 182
454	1426.28	161 883	504	1583.36	199 504	554	1740.44	241 051
455	1429.42	162 597	505	1586.50	200 296	555	1743.58	241 922
456	1432.57	163 313	506	1589.65	201 090	556	1746.73	242 795
457	1435.71	164 030	507	1592.79	201 886	557	1749.87	243 669
458	1438.85	164 748	508	1595.93	202 683	558	1753.01	244 545
459	1441.99	165 468	509	1599.07	203 482	559	1756.15	245 422
460	1445.13	166 190	510	1602.21	204 282	560	1759.29	246 301
461	1448.27	166 914	511	1605.35	205 084	561	1762.43	247 181
462	1451.42	167 639	512	1608.50	205 887	562	1765.58	248 063
463	1454.56	168 365	513	1611.64	206 692	563	1768.72	248 947
464	1457.70	169 093	514	1614.78	207 499	564	1771.86	249 832
465	1460.84	169 823	515	1617.92	208 307	565	1775.00	250 719
466	1463.98	170 554	516	1621.06	209 117	566	1778.14	251 607
467	1467.12	171 287	517	1624.20	209 928	567	1781.28	252 497
468	1470.27	172 021	518	1627.35	210 741	568	1784.42	253 388
469	1473.41	172 757	519	1630.49	211 556	569	1787.57	254 281
470	1476.55	173 494	520	1633.63	212 372	570	1790.71	255 176
471	1479.69	174 234	521	1636.77	213 189	571	1793.85	256 072
472	1482.83	174 974	522	1639.91	214 008	572	1796.99	256 970
473	1485.97	175 716	523	1643.05	214 829	573	1800.13	257 869
474	1489.11	176 460	524	1646.20	215 651	574	1803.27	258 770
475	1492.26	177 205	525	1649.34	216 475	575	1806.42	259 672
476	1495.40	177 952	526	1652.48	217 301	576	1809.56	260 576
477	1498.54	178 701	527	1655.62	218 128	577	1812.70	261 482
478	1501.68	179 451	528	1658.76	218 956	578	1815.84	262 389
479	1504.82	180 203	529	1661.90	219 787	579	1818.98	263 298
480	1507.96	180 956	530	1665.04	220 618	580	1822.12	264 208
481	1511.11	181 711	531	1668.19	221 452	581	1825.27	265 120
482	1514.25	182 467	532	1671.33	222 287	582	1828.41	266 033
483	1517.39	183 225	533	1674.47	223 123	583	1831.55	266 948
484	1520.53	183 984	534	1677.61	223 961	584	1834.69	267 865
485	1523.67	184 745	535	1680.75	224 801	585	1837.83	268 783
486	1526.81	185 508	536	1683.89	225 642	586	1840.97	269 702
487	1529.96	186 272	537	1687.04	226 484	587	1844.11	270 624
488	1533.10	187 038	538	1690.18	227 329	588	1847.26	271 547
489	1536.24	187 806	539	1693.32	228 175	589	1850.40	272 471
490	1539.38	188 574	540	1696.46	229 022	590	1853.54	273 397
491	1542.52	189 345	541	1699.60	229 871	591	1856.68	274 325
492	1545.66	190 117	542	1702.74	230 722	592	1859.82	275 254
493	1548.81	190 890	543	1705.88	231 574	593	1862.96	276 184
494	1551.95	191 665	544	1709.03	232 428	594	1866.11	277 117
495	1555.09	192 442	545	1712.17	233 283	595	1869.25	278 051
496	1558.23	193 221	546	1715.31	234 140	596	1872.39	278 986
497	1561.37	194 000	547	1718.45	234 998	597	1875.53	279 923
498	1564.51	194 782	548	1721.59	235 858	598	1878.67	280 862
499	1567.65	195 565	549	1724.73	236 720	599	1881.81	281 802
500	1570.80	196 350	550	1727.88	237 583	600	1884.96	282 7[illegible]

Diameter.	Circum.	Area.	Diameter.	Circum.	Area.	Diameter.	Circum.	Area.
601	1888.10	283 687	651	2045.18	332 853	701	2202.26	385 945
602	1891.24	284 631	652	2048.32	333 876	702	2205.40	387 047
603	1894.38	285 578	653	2051.46	334 901	703	2208.54	388 151
604	1897.52	286 526	654	2054.60	335 927	704	2211.68	389 256
605	1900.66	287 475	655	2057.74	336 955	705	2214.82	390 363
606	1903.81	288 426	656	2060.88	337 985	706	2217.96	391 471
607	1906.95	289 379	657	2064.03	339 016	707	2221.11	392 580
608	1910.09	290 333	658	2067.17	340 049	708	2224.25	393 692
609	1913.23	291 289	659	2070.31	341 083	709	2227.39	394 805
610	1916.37	292 247	660	2073.45	342 119	710	2230.53	395 919
611	1919.51	293 206	661	2076.59	343 157	711	2233.67	397 035
612	1922.65	294 166	662	2079.73	344 196	712	2236.81	398 153
613	1925.80	295 128	663	2082.88	345 237	713	2239.96	399 272
614	1928.94	296 092	664	2086.02	346 279	714	2243.10	400 393
615	1932.08	297 057	665	2089.16	347 323	715	2246.24	401 515
616	1935.22	298 024	666	2092.30	348 368	716	2249.38	402 639
617	1938.36	298 992	667	2095.44	349 415	717	2252.52	403 765
618	1941.50	299 962	668	2098.58	350 464	718	2255.66	404 892
619	1944.65	300 934	669	2101.73	351 514	719	2258.81	406 020
620	1947.79	301 907	670	2104.87	352 565	720	2261.95	407 150
621	1950.93	302 882	671	2108.01	353 618	721	2265.09	408 282
622	1954.07	303 858	672	2111.15	354 673	722	2268.23	409 416
623	1957.21	304 836	673	2114.29	355 730	723	2271.37	410 550
624	1960.35	305 815	674	2117.43	356 788	724	2274.51	411 687
625	1963.50	306 796	675	2120.58	357 847	725	2277.65	412 825
626	1966.64	307 779	676	2123.72	358 908	726	2280.80	413 965
627	1969.78	308 763	677	2126.86	359 971	727	2283.94	415 106
628	1972.92	309 748	678	2130.00	361 035	728	2287.08	416 248
629	1976.06	310 736	679	2133.14	362 101	729	2290.22	417 393
630	1979.20	311 725	680	2136.28	363 168	730	2293.36	418 539
631	1982.35	312 715	681	2139.42	364 237	731	2296.50	419 686
632	1985.49	313 707	682	2142.57	365 308	732	2299.65	420 835
633	1988.63	314 700	683	2145.71	366 380	733	2302.79	421 986
634	1991.77	315 696	684	2148.85	367 453	734	2305.93	423 139
635	1994.91	316 692	685	2151.99	368 528	735	2309.07	424 292
636	1998.05	317 690	686	2155.13	369 605	736	2312.21	425 447
637	2001.19	318 690	687	2158.27	370 684	737	2315.35	426 604
638	2004.34	319 692	688	2161.42	371 764	738	2318.50	427 762
639	2007.48	320 695	689	2164.56	372 845	739	2321.64	428 922
640	2010.62	321 699	690	2167.70	373 928	740	2324.78	430 084
641	2013.67	322 705	691	2170.84	375 013	741	2327.92	431 247
642	2016.90	323 713	692	2173.98	376 099	742	2331.06	432 412
643	2020.04	324 722	693	2177.12	377 187	743	2334.30	433 578
644	2023.19	325 733	694	2180.27	378 276	744	2337.34	434 746
645	2026.33	326 745	695	2183.41	379 367	745	2340.49	435 916
646	2029.47	327 759	696	2186.55	380 459	746	2343.63	437 087
647	2032.61	328 775	697	2189.69	381 554	747	2346.77	438 259
648	2035.75	329 792	698	2192.83	382 649	748	2349.91	439 433
649	2038.89	330 810	699	2195.97	383 746	749	2353.05	440 609
650	2042.04	331 831	700	2199.11	384 845	750	2356.19	441 78[illegible]

Diameter.	Circum.	Area.	Diameter.	Circum.	Area.	Diameter.	Circum.	Area.
751	2359.34	442 965	801	2516.42	503 912	851	2673.50	568 786
752	2362.48	444 146	802	2519.56	505 171	852	2676.64	570 124
753	2365.62	445 328	803	2522.70	506 432	853	2679.78	571 463
754	2368.76	446 511	804	2525.84	507 694	854	2682.92	572 803
755	2371.90	447 697	805	2528.98	508 958	855	2686.06	574 146
756	2375.04	448 883	806	2532.12	510 223	856	2689.20	575 490
757	2378.19	450 072	807	2535.27	511 490	857	2692.34	576 835
758	2381.33	451 262	808	2538.41	512 758	858	2695.49	578 182
759	2384.47	452 453	809	2541.55	514 028	859	2698.63	579 530
760	2387.61	453 646	810	2544.69	515 300	860	2701.77	580 880
761	2390.75	454 841	811	2547.83	516 573	861	2704.91	582 232
762	2393.89	456 037	812	2550.97	517 848	862	2708.05	583 585
763	2397.04	457 234	813	2554.11	519 124	863	2711.19	584 940
764	2400.18	458 434	814	2557.26	520 402	864	2714.34	586 297
765	2403.32	459 635	815	2560.40	521 681	865	2717.48	587 655
766	2406.46	460 837	816	2563.54	522 962	866	2720.62	589 014
767	2409.60	462 041	817	2566.68	524 245	867	2723.76	590 375
768	2412.74	463 247	818	2569.82	525 529	868	2726.90	591 738
769	2415.88	464 454	819	2572.96	526 814	869	2730.04	593 102
770	2419.03	465 663	820	2576.11	528 102	870	2733.19	594 468
771	2422.17	466 873	821	2579.25	529 391	871	2736.33	595 835
772	2425.31	468 085	822	2582.39	530 681	872	2739.47	597 204
773	2428.45	469 298	823	2585.53	531 973	873	2742.61	598 575
774	2431.59	470 513	824	2588.67	533 267	874	2745.75	599 947
775	2434.73	471 730	825	2591.81	534 562	875	2748.89	601 320
776	2437.88	472 948	826	2594.96	535 858	876	2752.04	602 696
777	2441.02	474 168	827	2598.10	537 157	877	2755.18	604 073
778	2444.16	475 389	828	2601.24	538 456	878	2758.32	605 451
779	2447.30	476 612	829	2604.38	539 758	879	2761.46	606 831
780	2450.44	477 836	830	2607.52	541 061	880	2764.60	608 212
781	2453.58	479 062	831	2610.66	542 365	881	2767.74	609 595
782	2456.73	480 290	832	2613.81	543 671	882	2770.88	61[illegible]
783	2459.87	481 519	833	2616.95	544 979	883	2774.03	612 366
784	2463.01	482 750	834	2620.09	546 288	884	2777.17	613 754
785	2466.15	483 982	835	2623.23	547 599	885	2780.31	615 143
786	2469.29	485 216	836	2626.37	548 912	886	2783.45	616 534
787	2472.43	486 451	837	2629.51	550 226	887	2786.59	617 927
788	2475.58	487 688	838	2632.65	551 541	888	2789.73	619 321
789	2478.72	488 927	839	2635.80	552 858	889	2792.88	620 717
790	2481.86	490 167	840	2638.94	554 177	890	2796.02	622 114
791	2485.00	491 409	841	2642.08	555 497	891	2799.16	623 513
792	2488.14	492 652	842	2645.22	556 819	892	2802.30	624 913
793	2491.28	493 897	843	2648.36	558 142	893	2805.44	626 315
794	2494.42	495 143	844	2651.50	559 467	894	2808.58	627 718
795	2497.57	496 391	845	2654.65	560 794	895	2811.73	629 124
796	2500.71	497 641	846	2657.79	562 122	896	2814.87	630 530
797	2503.85	498 892	847	2660.93	563 452	897	2818.01	631 938
798	2506.99	500 145	848	2664.07	564 783	898	2821.15	633 348
799	2510.13	501 399	849	2667.21	566 116	899	2824.29	634 760
800	2513.27	502 655	850	2670.35	567 450	900	2827.43	636 173

Diameter.	Circum.	Area.	Diameter.	Circum.	Area.	Diameter.	Circum.	Area.
901	2830.58	637 587	934	2934.25	685 147	967	3037.92	734 417
902	2833.72	639 003	935	2937.39	686 615	968	3041.06	735 937
903	2836.86	640 421	936	2940.53	688 084	969	3044.20	737 458
904	2840.00	641 840	937	2943.67	689 555	970	3047.34	738 981
905	2843.14	643 261	938	2946.81	691 028	971	3050.49	740 506
906	2846.28	644 683	939	2949.96	692 502	972	3053.63	742 032
907	2849.42	646 107	940	2953.10	693 978	973	3056.77	743 559
908	2852.57	647 533	941	2956.24	695 455	974	3059.91	745 088
909	2855.71	648 960	942	2959.38	696 934	975	3063.05	746 619
910	2858.85	650 388	943	2962.52	698 415	976	3066.19	748 151
911	2861.99	651 818	944	2965.66	699 897	977	3069.34	749 685
912	2865.13	653 250	945	2968.81	701 380	978	3072.48	751 221
913	2868.27	654 684	946	2971.95	702 865	979	3075.62	752 758
914	2871.42	656 118	947	2975.09	704 352	980	3078.76	754 296
915	2874.56	657 555	948	2978.23	705 840	981	3081.90	755 837
916	2877.70	658 993	949	2981.37	707 330	982	3085.04	757 378
917	2880.84	660 433	950	2984.51	708 822	983	3088.19	758 922
918	2883.98	661 874	951	2987.65	710 315	984	3091.33	760 466
919	2887.12	663 317	952	2990.80	711 809	985	3094.47	762 013
920	2890.27	664 761	953	2993.94	713 307	986	3097.61	763 561
921	2893.41	666 207	954	2997.08	714 803	987	3100.75	765 111
922	2896.55	667 654	955	3000.22	716 303	988	3103.89	766 662
923	2899.69	669 103	956	3003.36	717 804	989	3107.04	768 215
924	2902.83	670 554	957	3006.50	719 306	990	3110.18	769 769
925	2905.97	672 006	958	3009.65	720 810	991	3113.32	771 325
926	2909.11	673 460	959	3012.79	722 316	992	3116.46	772 882
927	2912.26	674 915	960	3015.93	723 823	993	3119.60	774 441
928	2915.40	676 372	961	3019.07	725 332	994	3122.74	776 002
929	2918.54	677 831	962	3022.21	726 842	995	3125.88	777 564
930	2921.68	679 291	963	3025.35	728 354	996	3129.03	779 128
931	2924.82	680 752	964	3028.50	729 867	997	3132.17	780 693
932	2927.96	682 216	965	3031.64	731 382	998	3135.31	782 260
933	2931.11	683 680	966	3034.78	732 899	999	3138.45	783 828

NOTE.—When it is desired to find the circumference corresponding to any diameter not in the table, point off as many places in the circumference as have been pointed off in the diameter, and point off twice as many places in this area as have been pointed off in the diameter. Thus:

Diameters.	*Circumferences.*	*Areas.*
9.16	28.777	65.8993
91.6	287.77	6 589.93
916.	2877.7	658 993.
9160.	28777.	65 899 321.

When it is desired to find the circumference or area for any diameter consisting of a whole number and a decimal, it may be done by taking the difference between the tabular figures for the diameters between which the given diameter lies and multiplying this difference by the decimal and adding the result to the tabular value corresponding to the next low diameter.

POWERS AND ROOTS.

Number.	Squares.	Cubes.	√ Roots.	∛ Roots.	Reciprocals.
1	1	1	1.000 0000	1.000 0000	1.000 000 000
2	4	8	1.414 2136	1.259 9210	.500 000 000
3	9	27	1.732 0508	1.442 2496	.333 333 333
4	16	64	2.000 0000	1.587 4011	.250 000 000
5	25	125	2.236 0680	1.709 9759	.200 000 000
6	36	216	2.449 4897	1.817 1206	.166 666 667
7	49	343	2.645 7513	1.912 9312	.142 857 143
8	64	512	2.828 4271	2.000 0000	.125 000 000
9	81	729	3.000 0000	2.080 0837	.111 111 111
10	100	1 000	3.162 2777	2.154 4347	.100 000 000
11	121	1 331	3.316 6248	2.223 9801	.090 909 091
12	144	1 728	3.464 1016	2.289 4286	.083 333 333
13	169	2 197	3.605 5513	2.351 3347	.076 923 077
14	196	2 744	3.741 6574	2.410 1422	.071 428 571
15	225	3 375	3.872 9833	2.466 2121	.066 666 667
16	256	4 096	4.000 0000	2.519 8421	.062 500 000
17	289	4 913	4.123 1056	2.571 2816	.058 823 529
18	324	5 832	4.242 6407	2.620 7414	.055 555 556
19	361	6 859	4.358 8989	2.668 4016	.052 631 579
20	400	8 000	4.472 1360	2.714 4177	.050 000 000
21	441	9 261	4.582 5757	2.758 9243	.047 619 048
22	484	10 648	4.690 4158	2.802 0393	.045 454 545
23	529	12 167	4.795 8315	2.843 8670	.043 478 261
24	576	13 824	4.898 9795	2.884 4991	.041 666 667
25	625	15 625	5.000 0000	2.924 0177	.040 000 000
26	676	17 576	5.099 0195	2.962 4960	.038 461 538
27	729	19 683	5.196 1524	3.000 0000	.037 037 037
28	784	21 952	5.291 5026	3.036 5889	.035 714 286
29	841	24 389	5.385 1648	3.072 3168	.034 482 759
30	900	27 000	5.477 2256	3.107 2325	.033 333 333
31	961	29 791	5.567 7644	3.141 3806	.032 258 065
32	1 024	32 768	5.656 8542	3.174 8021	.031 250 000
33	1 089	35 937	5.744 5626	3.207 5343	.030 303 030
34	1 156	39 304	5.830 9519	3.239 6118	.029 411 765
35	1 225	42 875	5.916 0798	3.271 0663	.028 571 429
36	1 296	46 656	6.000 0000	3.301 9272	.027 777 778
37	1 369	50 653	6.082 7625	3.332 2218	.027 027 027
38	1 444	54 872	6.164 4140	3.361 9754	.026 315 789
39	1 521	59 319	6.244 9980	3.391 2114	.025 641 026
40	1 600	64 000	6.324 5553	3.419 9519	.025 000 000
41	1 681	68 921	6.403 1242	3.448 2172	.024 390 244
42	1 764	74 088	6.480 7407	3.476 0266	.023 809 524
43	1 849	79 507	6.557 4385	3.503 3981	.023 255 814
44	1 936	85 184	6.633 2496	3.530 3483	.022 727 273
45	2 025	91 125	6.708 2039	3.556 8933	.022 222 222
46	2 116	97 336	6.782 3300	3.583 0479	.021 739 130
47	2 209	103 823	6.855 6546	3.608 8261	.021 276 600
48	2 304	110 592	6.928 2032	3.634 2411	.020 833 333
49	2 401	117 649	7.000 0000	3.659 3057	.020 408 163
50	2 500	125 000	7.071 0678	3.684 0314	.020 000 000
51	2 601	132 651	7.141 4284	3.708 4298	.019 607 843
52	2 704	140 608	7.211 1026	3.732 5111	.019 230 76

Number.	Squares.	Cubes.	√ Roots.	∛ Roots.	Reciprocals.
53	2 809	148 877	7.280 1099	3.756 2858	.018 867 925
54	2 916	157 464	7.348 4692	3.779 7631	.018 518 519
55	3 025	166 375	7.416 1985	3.802 9525	.018 181 818
56	3 136	175 616	7.483 3148	3.825 8624	.017 857 143
57	3 249	185 193	7.549 8344	3.848 5011	.017 543 860
58	3 364	195 112	7.615 7731	3.870 8766	.017 241 379
59	3 481	205 379	7.681 1457	3.892 9965	.016 949 153
60	3 600	216 000	7.745 9667	3.914 8676	.016 666 667
61	3 721	226 981	7.810 2497	3.930 4972	.016 393 443
62	3 844	238 328	7.874 0079	3.957 8915	.016 129 032
63	3 969	250 047	7.937 2539	3.979 0571	.015 873 016
64	4 096	262 144	8.000 0000	4.000 0000	.015 625 000
65	4 225	274 625	8.062 2577	4.020 7256	.015 384 615
66	4 356	287 496	8.124 0384	4.041 2401	.015 151 515
67	4 489	300 763	8.185 3528	4.061 5480	.014 925 373
68	4 624	314 432	8.246 2113	4.081 6551	.014 705 882
69	4 761	328 509	8.306 6239	4.101 5661	.014 492 754
70	4 900	343 000	8.366 6003	4.121 2853	.014 285 714
71	5 041	357 911	8.426 1498	4.140 8178	.014 084 517
72	5 184	373 248	8.485 2814	4.160 1676	.013 888 889
73	5 329	389 017	8.544 0037	4.179 3390	.013 698 630
74	5 476	405 224	8.602 3253	4.198 3364	.013 513 514
75	5 625	421 875	8.660 2540	4.217 1633	.013 333 333
76	5 776	438 976	8.717 7979	4.235 8236	.013 157 895
77	5 929	456 533	8.774 9644	4.254 3210	.012 987 013
78	6 084	474 552	8.831 7609	4.272 6586	.012 820 513
79	6 241	493 039	8.888 1944	4.290 8404	.012 658 228
80	6 400	512 000	8.944 2719	4.308 8695	.012 500 000
81	6 561	531 441	9.000 0000	4.326 7487	.012 345 679
82	6 724	551 368	9.055 3851	4.344 4815	.012 195 122
83	6 889	571 787	9.110 4336	4.362 0707	.012 048 193
84	7 056	592 704	9.165 1514	4.379 5191	.011 904 762
85	7 225	614 125	9.219 5445	4.396 8296	.011 764 706
86	7 396	636 056	9.273 6185	4.414 0049	.011 627 907
87	7 569	658 503	9.327 3791	4.431 0476	.011 494 253
88	7 744	681 472	9.380 8315	4.447 9692	.011 363 636
89	7 921	704 969	9.433 9811	4.464 7451	.011 235 955
90	8 100	729 000	9.486 8330	4.481 4047	.011 111 111
91	8 281	753 571	9.539 3920	4.497 9414	.010 989 011
92	8 464	778 688	9.591 6630	4.514 3574	.010 869 565
93	8 649	804 357	9.643 6508	4.530 6549	.010 752 688
94	8 836	830 584	9.695 3597	4.546 8359	.010 638 298
95	9 025	857 375	9.746 7943	4.562 9026	.010 526 316
96	9 216	884 736	9.797 9590	4.578 8570	.010 416 667
97	9 409	912 673	9.848 8578	4.594 7009	.010 309 278
98	9 604	941 192	9.899 4949	4.610 4363	.010 204 082
99	9 801	970 299	9.949 8744	4.626 0650	.010 101 010
100	10 000	1 000 000	10.000 0000	4.641 5888	.010 000 000
101	*10 201*	1 030 301	10.049 8756	4.657 0095	.009 900 990
102	*10 404*	1 061 208	10.099 5049	4.672 3287	.009 803 922
103	*10 609*	1 092 727	10.148 8916	4.687 5482	.009 708 738
104	*10 816*	1 124 864	10.198 0390	4.702 6694	.009 615 385

Number.	Squares.	Cubes.	√ Roots.	∛ Roots.	Reciprocals.
105	11 025	1 157 625	10.246 9508	4.717 6940	.009 523 810
106	11 236	1 191 016	10.295 6301	4.732 6235	.009 433 962
107	11 449	1 225 043	10.344 0804	4.747 4594	.009 345 794
108	11 664	1 259 712	10.392 3048	4.762 2032	.009 259 259
109	11 881	1 295 029	10.440 3065	4.776 8562	.009 174 312
110	12 100	1 331 000	10.488 0885	4.791 4199	.009 090 909
111	12 321	1 367 631	10.535 6538	4.805 8995	.009 009 009
112	12 544	1 404 928	10.583 0052	4.820 2845	.008 928 571
113	12 769	1 442 897	10.630 1458	4.834 5881	.008 849 558
114	12 996	1 481 544	10.677 0783	4.848 8076	.008 771 930
115	13 225	1 520 875	10.723 8053	4.862 9442	.008 695 652
116	13 456	1 560 896	10.770 3296	4.876 9990	.008 620 690
117	13 689	1 601 613	10.816 6538	4.890 9732	.008 547 009
118	13 924	1 643 032	10.862 7805	4.904 8681	.008 474 576
119	14 161	1 685 159	10.908 7121	4.918 6847	.008 403 361
120	14 400	1 728 000	10.954 4512	4.932 4242	.008 333 333
121	14 641	1 771 561	11.000 0000	4.946 0874	.008 264 463
122	14 884	1 815 848	11.045 3610	4.959 6757	.008 196 721
123	15 129	1 860 867	11.090 5365	4.973 1898	.008 130 081
124	15 376	1 906 624	11.135 5287	4.986 6310	.008 064 516
125	15 625	1 953 125	11.180 3399	5.000 0000	.008 000 000
126	15 876	2 000 376	11.224 9722	5.013 2979	.007 936 508
127	16 129	2 048 383	11.269 4277	5.026 5257	.007 874 016
128	16 384	2 097 152	11.313 7085	5.039 6842	.007 812 500
129	16 641	2 146 689	11.357 8167	5.052 7743	.007 751 938
130	16 900	2 197 000	11.401 7543	5.065 7970	.007 692 308
131	17 161	2 248 091	11.445 5231	5.078 7531	.007 633 588
132	17 424	2 299 968	11.489 1253	5.091 6434	.007 575 758
133	17 689	2 352 637	11.532 5626	5.104 4687	.007 518 797
134	17 956	2 406 104	11.575 8369	5.117 2299	.007 462 687
135	18 225	2 460 375	11.618 9500	5.129 9278	.007 407 407
136	18 496	2 515 456	11.661 9038	5.142 5632	.007 352 941
137	18 769	2 571 353	11.704 6999	5.155 1367	.007 299 270
138	19 044	2 628 072	11.747 3401	5.167 6493	.007 246 377
139	19 321	2 685 619	11.789 8261	5.180 1015	.007 194 245
140	19 600	2 744 000	11.832 1596	5.192 4941	.007 142 857
141	19 881	2 803 221	11.874 3421	5.204 8279	.007 092 199
142	20 164	2 863 288	11.916 3753	5.217 1034	.007 042 254
143	20 449	2 924 207	11.958 2607	5.229 3215	.006 993 007
144	20 736	2 985 984	12.000 0000	5.241 4828	.006 944 444
145	21 025	3 048 625	12.041 5946	5.253 5879	.006 896 552
146	21 316	3 112 136	12.083 0460	5.265 6374	.006 849 315
147	21 609	3 176 523	12.124 3557	5.277 6321	.006 802 721
148	21 904	3 241 792	12.165 5251	5.289 5725	.006 756 757
149	22 201	3 307 949	12.206 5556	5.301 4592	.006 711 409
150	22 500	3 375 000	12.247 4487	5.313 2928	.006 666 667
151	22 801	3 442 951	12.288 2057	5.325 0740	.006 622 517
152	23 104	3 511 008	12.328 8280	5.336 8033	.006 578 947
153	23 409	3 581 577	12.369 3169	5.348 4812	.006 535 948
154	23 716	3 652 264	12.409 6736	5.360 1084	.006 493 506
155	24 025	3 723 875	12.449 8996	5.371 6854	.006 451 613
156	24 336	3 796 416	12.489 9960	5.383 2126	.006 410 256

Number.	Squares.	Cubes.	$\sqrt{}$ Roots.	$\sqrt[3]{}$ Roots.	Reciprocals.
157	24 649	3 869 893	12.529 9641	5.394 6907	.006 369 427
158	24 964	3 944 312	12.569 8051	5.406 1202	.006 329 114
159	25 281	4 019 679	12.609 5202	5.417 5015	.006 289 308
160	25 600	4 096 000	12.649 1106	5.428 8352	.006 250 000
161	25 921	4 173 281	12.688 5775	5.440 1218	.006 211 180
162	26 244	4 251 528	12.727 9221	5.451 3618	.006 172 840
163	26 569	4 330 747	12.767 1453	5.462 5556	.006 134 969
164	26 896	4 410 944	12.806 2485	5.473 7037	.006 097 561
165	27 225	4 492 125	12.845 2326	5.484 8066	.006 060 606
166	27 556	4 574 296	12.884 0987	5.495 8647	.006 024 096
167	27 889	4 657 463	12.922 8480	5.506 8784	.005 988 024
168	28 224	4 741 632	12.961 4814	5.517 8484	.005 952 381
169	28 561	4 826 809	13.000 0000	5.528 7748	.005 917 160
170	28 900	4 913 000	13.038 4048	5.539 6583	.005 882 353
171	29 241	5 000 211	13.076 6968	5.550 4991	.005 847 953
172	29 584	5 088 448	13.114 8770	5.561 2978	.005 813 953
173	29 929	5 177 717	13.152 9464	5.572 0546	.005 780 347
174	30 276	5 268 024	13.190 9060	5.582 7702	.005 747 126
175	30 625	5 359 375	13.228 7566	5.593 4447	.005 714 286
176	30 976	5 451 776	13.266 4992	5.604 0787	.005 681 818
177	31 329	5 545 233	13.304 1347	5.614 6724	.005 649 718
178	31 684	5 639 752	13.341 6641	5.625 2263	.005 617 978
179	32 041	5 735 339	13.379 0882	5.635 7408	.005 586 592
180	32 400	5 832 000	13.416 4079	5.646 2162	.005 555 556
181	32 761	5 929 741	13.453 6240	5.656 6528	.005 524 862
182	33 124	6 028 568	13.490 7376	5.667 0511	.005 494 505
183	33 489	6 128 487	13.527 7493	5.677 4114	.005 464 481
184	33 856	6 229 504	13.564 6600	5.687 7340	.005 434 783
185	34 225	6 331 625	13.601 4705	5.698 0192	.005 405 405
186	34 596	6 434 856	13.638 1817	5.708 2675	.005 376 344
187	34 969	6 539 203	13.674 7943	5.718 4791	.005 347 594
188	35 344	6 644 672	13.711 3092	5.728 6543	.005 319 149
189	35 721	6 751 269	13.747 7271	5.738 7936	.005 291 005
190	36 100	6 859 000	13.784 0488	5.748 8971	.005 263 158
191	36 481	6 967 871	13.820 2750	5.758 9652	.005 235 602
192	36 864	7 077 888	13.856 4065	5.768 9982	.005 208 333
193	37 249	7 189 517	13.892 4400	5.778 9966	.005 181 347
194	37 636	7 301 384	13.928 3883	5.788 9604	.005 154 639
195	38 025	7 414 875	13.964 2400	5.798 8900	.005 128 205
196	38 416	7 529 536	14.000 0000	5.808 7857	.005 102 041
197	38 809	7 645 373	14.035 6688	5.818 6479	.005 076 142
198	39 204	7 762 392	14.071 2473	5.828 4867	.005 050 505
199	39 601	7 880 599	14.106 7360	5.838 2725	.005 025 126
200	40 000	8 000 000	14.142 1356	5.848 0355	.005 000 000
201	40 401	8 120 601	14.177 4469	5.857 7660	.004 975 124
202	40 804	8 242 408	14.212 6704	5.867 4673	.004 950 495
203	41 209	8 365 427	14.247 8068	5.877 1307	.004 926 108
204	41 616	8 489 664	14.282 8569	5.886 7653	.004 901 961
205	42 025	8 615 125	14.317 8211	5.896 3685	.004 878 049
206	42 436	8 741 816	14.352 7001	5.905 9406	.004 854 369
207	42 849	8 869 743	14.387 4946	5.915 4817	.004 830 918
208	43 264	8 998 912	14.422 2051	5.924 9921	.004 807 69[illegible]

Number.	Squares.	Cubes.	√ Roots.	∛ Roots.	Reciprocals.
209	43 681	9 129 329	14.456 8323	5.934 4721	.004 784 689
210	44 100	9 261 000	14.491 3767	5.943 9220	.004 761 905
211	44 521	9 393 931	14.525 8390	5.953 3418	.004 739 336
212	44 944	9 528 128	14.560 2198	5.962 7320	.004 716 981
213	45 369	9 663 597	14.594 5195	5.972 0926	.004 694 836
214	45 796	9 800 341	14.628 7388	5.981 4240	.004 672 897
215	46 225	9 938 375	14.662 8783	5.990 7264	.004 651 163
216	46 656	10 077 696	14.696 9385	6.000 0000	.004 629 630
217	47 089	10 218 313	14.730 9199	6.009 2450	.004 608 295
218	47 524	10 360 232	14.764 8231	6.018 4617	.004 587 156
219	47 961	10 503 459	14.798 6486	6.027 6502	.004 566 210
220	48 400	10 648 000	14.832 3970	6.036 8107	.004 545 455
221	48 841	10 793 861	14.866 0687	6.045 9435	.004 524 887
222	49 284	10 941 048	14.899 6644	6.055 0489	.004 504 505
223	49 729	11 089 567	14.933 1845	6.064 1270	.004 484 305
224	50 176	11 239 424	14.966 6295	6.073 1779	.004 464 286
225	50 625	11 390 625	15.000 0000	6.082 4020	.004 444 444
226	51 076	11 543 176	15.033 2964	6.099 1994	.004 424 779
227	51 529	11 697 083	15.066 5192	6.100 1702	.004 405 286
228	51 984	11 852 352	15.099 6689	6.109 1147	.004 385 965
229	52 441	12 008 989	15.132 7460	6.118 0332	.004 366 812
230	52 900	12 167 000	15.165 7509	6.126 9257	.004 347 826
231	53 361	12 326 391	15.198 6842	6.135 7924	.004 329 004
232	53 824	12 487 168	15.231 5462	6.144 6337	.004 310 345
233	54 289	12 649 337	15.264 3375	6.153 4495	.004 291 845
234	54 756	12 812 904	15.297 0585	6.162 2401	.004 273 504
235	55 225	12 977 875	15.329 7097	6.171 0058	.004 255 319
236	55 696	13 144 256	15.362 2915	6.179 7466	.004 237 288
237	56 169	13 312 053	15.394 8043	6.188 4628	.004 219 409
238	56 644	13 481 272	15.427 2486	6.197 1544	.004 201 681
239	57 121	13 651 919	15.459 6248	6.205 8218	.004 184 100
240	57 600	13 824 000	15.491 9334	6.214 4650	.004 166 667
241	58 081	13 997 521	15.524 1747	6.223 0843	.004 149 378
242	58 564	14 172 488	15.556 3492	6.231 6797	.004 132 231
243	59 049	14 348 907	15.588 4573	6.240 2515	.004 115 226
244	59 536	14 526 784	15.620 4994	6.248 7998	.004 098 361
245	60 025	14 706 125	15.652 4758	6.257 3248	.004 081 633
246	60 516	14 886 936	15.684 3871	6.265 8266	.004 065 041
247	61 009	15 069 223	15.716 2336	6.274 3054	.004 048 583
248	61 504	15 252 992	15.748 0157	6.282 7613	.004 032 258
249	62 001	15 438 249	15.779 7338	6.291 1946	.004 016 064
250	62 500	15 625 000	15.811 3883	6.299 6053	.004 000 000
251	63 001	15 813 251	15.842 9795	6.307 9935	.003 984 064
252	63 504	16 003 008	15.874 5079	6.316 3596	.003 968 254
253	64 009	16 194 277	15.905 9737	6.324 7035	.003 952 569
254	64 516	16 387 064	15.937 3775	6.333 0256	.003 937 008
255	65 025	16 581 375	15.968 7194	6.341 3257	.003 921 569
256	65 536	16 777 216	16.000 0000	6.349 6042	.003 906 250
257	66 049	16 974 593	16.031 2195	6.357 8611	.003 891 051
258	66 564	17 173 512	16.062 3784	6.366 0968	.003 875 969
259	67 081	17 373 979	16.093 4769	6.374 3111	.003 861 004
260	67 600	17 576 000	16.124 5155	6.382 5043	.003 846 154

Number.	Squares.	Cubes.	$\sqrt{}$ Roots.	$\sqrt[3]{}$ Roots.	Reciprocals.
261	68 121	17 779 581	16.155 4944	6.390 6765	.003 831 418
262	68 644	17 984 728	16.186 4141	6.398 8279	.003 816 794
263	69 169	18 191 447	16.217 2747	6.406 9585	.003 802 281
264	69 696	18 399 744	16.248 0768	6.415 0687	.003 787 879
265	70 225	18 609 625	16.278 8206	6.423 1583	.003 773 585
266	70 756	18 821 096	16.309 5064	6.431 2276	.003 759 398
267	71 289	19 034 163	16.340 1346	6.439 2767	.003 745 318
268	71 824	19 248 832	16.370 7055	6.447 3057	.003 731 343
269	72 361	19 465 109	16.401 2195	6.455 3148	.003 717 472
270	72 900	19 683 000	16.431 6767	6.463 3041	.003 703 704
271	73 441	19 902 511	16.462 0776	6.471 2736	.003 690 037
272	73 984	20 123 643	16.492 4225	6.479 2236	.003 676 471
273	74 529	20 346 417	16.522 7116	6.487 1541	.003 663 004
274	75 076	20 570 824	16.552 9454	6.495 0653	.003 649 635
275	75 625	20 796 875	16.583 1240	6.502 9572	.003 636 364
276	76 176	21 024 576	16.613 2477	6.510 8300	.003 623 188
277	76 729	21 253 933	16.643 3170	6.518 6839	.003 610 108
278	77 284	21 484 952	16.673 3320	6.526 5189	.003 597 122
279	77 841	21 717 639	16.703 2931	6.534 3351	.003 584 229
280	78 400	21 952 000	16.733 2005	6.542 1326	.003 571 429
281	78 961	22 188 041	16.763 0546	6.549 9116	.003 558 719
282	79 524	22 425 768	16.792 8556	6.557 6722	.003 546 099
283	80 089	22 665 187	16.822 6038	6.565 4144	.003 533 569
284	80 656	22 906 304	16.852 2995	6.573 1385	.003 521 127
285	81 225	23 149 125	16.881 9430	6.580 8443	.003 508 772
286	81 796	23 393 656	16.911 5345	6.588 5323	.003 496 503
287	82 369	23 639 903	16.941 0743	6.596 2023	.003 484 321
288	82 944	23 887 872	16.970 5627	6.603 8545	.003 472 222
289	83 521	24 137 569	17.000 0000	6.611 4890	.003 460 208
290	84 100	24 389 000	17.029 3864	6.619 1060	.003 448 276
291	84 681	24 642 171	17.058 7221	6.626 7054	.003 436 426
292	85 264	24 897 088	17.088 0075	6.634 2874	.003 424 658
293	85 849	25 153 757	17.117 2428	6.641 8522	.003 412 969
294	86 436	25 412 184	17.146 4282	6.649 3998	.003 401 361
295	87 025	25 672 375	17.175 5640	6.656 9302	.003 389 831
296	87 616	25 934 836	17.204 6505	6.664 4437	.003 378 378
297	88 209	26 198 073	17.233 6879	6.671 9403	.003 367 003
298	88 804	26 463 592	17.262 6765	6.679 4200	.003 355 705
299	89 401	26 730 899	17.291 6165	6.686 8831	.003 344 482
300	90 000	27 000 000	17.320 5081	6.694 3295	.003 333 333
301	90 601	27 270 901	17.349 3516	6.701 7593	.003 322 259
302	91 204	27 543 608	17.378 1472	6.709 1729	.003 311 258
303	91 809	27 818 127	17.406 8952	6.716 5700	.003 301 330
304	92 416	28 094 464	17.435 5958	6.723 9508	.003 289 474
305	93 025	28 372 625	17.464 2492	6.731 3155	.003 278 689
306	93 636	28 652 616	17.492 8557	6.738 6641	.003 267 974
307	94 249	28 934 443	17.521 4155	6.745 9967	.003 257 329
308	94 864	29 218 112	17.549 9288	6.753 3134	.003 246 753
309	95 481	29 503 609	17.578 3958	6.760 6143	.003 236 246
310	96 100	29 791 000	17.606 8169	6.767 8995	.003 225 806
311	96 721	30 080 231	17.635 1921	6.775 1690	.003 215 434
312	97 344	30 371 328	17.663 5217	6.782 4229	.003 205 128

Number	Squares.	Cubes.	$\sqrt{}$ Roots.	$\sqrt[3]{}$ Roots.	Reciprocals.
313	97 969	30 664 297	17.691 8060	6.789 6613	.003 194 888
314	98 596	30 959 144	17.720 0451	6.796 8844	.003 184 713
315	99 225	31 255 875	17.748 2393	6.804 0921	.003 174 603
316	99 856	31 554 496	17.776 3888	6.811 2847	.003 164 557
317	100 489	31 855 013	17.804 4938	6.818 4620	.003 154 574
318	101 124	32 157 432	17.832 5545	6.825 6242	.003 144 654
319	101 761	32 461 759	17.860 5711	6.832 7714	.003 134 796
320	102 400	32 768 000	17.888 5438	6.839 9037	.003 125 000
321	103 041	33 076 161	17.916 4729	6.847 0213	.003 115 265
322	103 684	33 386 248	17.944 3584	6.854 1240	.003 105 590
323	104 329	33 698 267	17.972 2008	6.861 2120	.003 095 975
324	104 976	34 012 224	18.000 0000	6.868 2855	.003 086 420
325	105 625	34 328 125	18.027 7564	6.875 3433	.003 076 923
326	106 276	34 645 976	18.055 4701	6.882 3888	.003 067 485
327	106 929	34 965 783	18.083 1413	6.889 4188	.003 058 104
328	107 584	35 287 552	18.110 7703	6.896 4345	.003 048 780
329	108 241	35 611 289	18.138 3571	6.903 4359	.003 039 514
330	108 900	35 937 000	18.165 9021	6.910 4232	.003 030 303
331	109 561	36 264 691	18.193 4054	6.917 3964	.003 021 148
332	110 224	36 594 368	18.220 8672	6.924 3556	.003 012 048
333	110 889	36 926 037	18.248 2876	6.931 3088	.003 003 003
334	111 556	37 259 704	18.275 6669	6.938 2321	.002 994 012
335	112 225	37 595 375	18.303 0052	6.945 1496	.002 985 075
336	112 896	37 933 056	18.330 3028	6.952 0533	.002 976 190
337	113 569	38 272 753	18.357 5598	6.958 9434	.002 967 359
338	114 244	38 614 472	18.384 7763	6.965 8198	.002 958 580
339	114 921	38 958 219	18.411 9526	6.972 6826	.002 949 853
340	115 600	39 304 000	18.439 0889	6.979 5321	.002 941 176
341	116 281	39 651 821	18.466 1853	6.986 3681	.002 932 551
342	116 964	40 001 688	18.493 2420	6.993 1906	.002 923 977
343	117 649	40 353 607	18.520 2592	7.000 0000	.002 915 452
344	118 336	40 707 584	18.547 2370	7.006 7962	.002 906 977
345	119 025	41 063 625	18.574 1756	7.013 5791	.002 898 551
346	119 716	41 421 736	18.601 0752	7.020 3490	.002 890 173
347	120 409	41 781 923	18.627 9360	7.027 1058	.002 881 844
348	121 104	42 144 192	18.654 7581	7.033 8497	.002 873 563
349	121 801	42 508 549	18.681 5417	7.040 5860	.002 865 330
350	122 500	42 875 000	18.708 2869	7.047 2987	.002 857 143
351	123 201	43 243 551	18.734 9940	7.054 0041	.002 849 003
352	123 904	43 614 208	18.761 6630	7.060 6967	.002 840 909
353	124 609	43 986 977	18.788 2942	7.067 3767	.002 832 861
354	125 316	44 361 864	18.814 8877	7.074 0440	.002 824 859
355	126 025	44 738 875	18.841 4437	7.080 6988	.002 816 901
356	126 736	45 118 016	18.867 9623	7.087 3411	.002 808 989
357	127 449	45 499 293	18.894 4436	7.093 9709	.002 801 120
358	128 164	45 882 712	18.920 8879	7.100 5855	.002 793 296
359	128 881	46 268 279	18.947 2953	7.107 1937	.002 785 515
360	129 600	46 656 000	18.973 6660	7.113 7866	.002 777 778
361	130 321	47 045 831	19.000 0000	7.120 3674	.002 770 083
362	131 044	47 437 928	19.026 2976	7.126 9360	.002 762 431
363	131 769	47 832 147	19.052 5589	7.133 4925	.002 754 82
364	132 496	48 228 544	19.078 7840	7.140 0370	.002 747 2

Number.	Squares.	Cubes.	$\sqrt{\text{Roots.}}$	$\sqrt[3]{\text{Roots.}}$	Reciprocals.
365	133 225	48 627 125	19.104 9732	7.146 5695	.002 739 726
366	133 956	49 027 896	19.131 1265	7.153 0901	.002 732 240
367	134 689	49 430 863	19.157 2441	7.159 5988	.002 724 796
368	135 424	49 836 032	19.183 3261	7.166 0957	.002 717 391
369	136 161	50 243 409	19.209 3727	7.172 5809	.002 710 027
370	136 900	50 653 000	19.235 3841	7.179 0544	.002 702 703
371	137 641	51 064 811	19.261 3603	7.185 5162	.002 695 418
372	138 384	51 478 848	19.287 3015	7.191 9663	.002 688 172
373	139 129	51 895 117	19.313 2079	7.198 4050	.002 680 965
374	139 876	52 313 624	19.339 0796	7.204 8322	.002 673 797
375	140 625	52 734 375	19.364 9167	7.211 2479	.002 666 667
376	141 376	53 157 376	19.390 7194	7.217 6522	.002 659 574
377	142 129	53 582 633	19.416 4878	7.224 0450	.002 652 520
378	142 884	54 010 152	19.442 2221	7.230 4268	.002 645 503
379	143 641	54 439 939	19.467 9223	7.236 7972	.002 638 521
380	144 400	54 872 000	19.493 5887	7.243 1565	.002 631 579
381	145 161	55 306 341	19.519 2213	7.249 5045	.002 624 672
382	145 924	55 742 968	19.544 8203	7.255 8415	.002 617 801
383	146 689	56 181 887	19.570 3858	7.262 1675	.002 610 966
384	147 456	56 623 104	19.595 9179	7.268 4824	.002 604 167
385	148 225	57 066 625	19.621 4169	7.274 7864	.002 597 403
386	148 996	57 512 456	19.646 8827	7.281 0794	.002 590 674
387	149 769	57 960 603	19.672 3156	7.287 3617	.002 583 979
388	150 544	58 411 072	19.697 7156	7.293 6330	.002 577 320
389	151 321	58 863 869	19.723 0829	7.299 8936	.002 570 694
390	152 100	59 319 000	19.748 4177	7.306 1436	.002 564 103
391	152 881	59 776 471	19.773 7199	7.312 3828	.002 557 545
392	153 664	60 236 288	19.798 9899	7.318 6114	.002 551 020
393	154 449	60 698 457	19.824 2276	7.324 8295	.002 544 529
394	155 236	61 162 984	19.849 4332	7.331 0369	.002 538 071
395	156 025	61 629 875	19.874 6069	7.337 2339	.002 531 646
396	156 816	62 099 136	19.899 7487	7.343 4205	.002 525 253
397	157 609	62 570 773	19.924 8588	7.349 5966	.002 518 892
398	158 404	63 044 792	19.949 9373	7.355 7624	.002 512 563
399	159 201	63 521 199	19.974 9844	7.361 9178	.002 506 266
400	160 000	64 000 000	20.000 0000	7.368 0630	.002 500 000
401	160 801	64 481 201	20.024 9844	7.374 1979	.002 493 766
402	161 604	64 964 808	20.049 9377	7.380 3227	.002 487 562
403	162 409	65 450 827	20.074 8599	7.386 4373	.002 481 390
404	163 216	65 939 264	20.099 7512	7.392 5418	.002 475 248
405	164 025	66 430 125	20.124 6118	7.398 6363	.002 469 136
406	164 836	66 923 416	20.149 4417	7.404 7206	.002 463 054
407	165 649	67 419 143	20.174 2410	7.410 7950	.002 457 002
408	166 464	67 917 312	20.199 0099	7.416 8595	.002 450 980
409	167 281	68 417 929	20.223 7484	7.422 9142	.002 444 988
410	168 100	68 921 000	20.248 4567	7.428 9589	.002 439 024
411	168 921	69 426 531	20.273 1349	7.434 9938	.002 433 090
412	169 744	69 934 528	20.297 7831	7.441 0189	.002 427 184
413	170 569	70 444 997	20.322 4014	7.447 0343	.002 421 308
414	171 396	70 957 944	20.346 9899	7.453 0399	.002 415 459
415	172 225	71 473 375	20.371 5488	7.459 0359	.002 409 639
416	173 056	71 991 296	20.396 0781	7.465 0223	.002 406 846

Number.	Squares.	Cubes.	$\sqrt{\ }$ Roots.	$\sqrt[3]{\ }$ Roots.	Reciprocals.
417	173 889	72 511 713	20.420 5779	7.470 9991	.002 398 082
418	174 724	73 034 632	20.445 0483	7.476 9664	.002 392 344
419	175 561	73 560 059	20.469 4895	7.482 9242	.002 386 635
420	176 400	74 088 000	20.493 9015	7.488 8724	.002 380 952
421	177 241	74 618 461	20.518 2845	7.494 8113	.002 375 297
422	178 084	75 151 448	20.542 6386	7.500 7406	.002 369 668
423	178 929	75 686 967	20.566 9638	7.506 6607	.002 364 066
424	179 776	76 225 024	20.591 2603	7.512 5715	.002 358 491
425	180 625	76 765 625	20.615 5281	7.518 4730	.002 352 941
426	181 476	77 308 776	20.639 7674	7.524 3652	.002 347 418
427	182 329	77 854 483	20.663 9783	7.530 2482	.002 341 920
428	183 184	78 402 752	20.688 1609	7.536 1221	.002 336 449
429	184 041	78 953 589	20.712 3152	7.541 9867	.002 331 002
430	184 900	79 507 000	20.736 4414	7.547 8423	.002 325 581
431	185 761	80 062 991	20.760 5395	7.553 6888	.002 320 186
432	186 624	80 621 568	20.784 6097	7.559 5263	.002 314 815
433	187 489	81 182 737	20.808 6520	7.565 3548	.002 309 469
434	188 356	81 746 504	20.832 6667	7.571 1743	.002 304 147
435	189 225	82 312 875	20.856 6536	7.576 9849	.002 298 851
436	190 096	82 881 856	20.880 6130	7.582 7865	.002 293 578
437	190 969	83 453 453	20.904 5450	7.588 5793	.002 288 330
438	191 844	84 027 672	20.928 4495	7.594 3633	.002 283 105
439	192 721	84 604 519	20.952 3268	7.600 1385	.002 277 904
440	193 600	85 184 000	20.976 1770	7.605 9049	.002 272 727
441	194 481	85 766 121	21.000 0000	7.611 6626	.002 267 574
442	195 364	86 350 888	21.023 7960	7.617 4116	.002 262 443
443	196 249	86 938 307	21.047 5652	7.623 1519	.002 257 336
444	197 136	87 528 384	21.071 3075	7.628 8837	.002 252 252
445	198 025	88 121 125	21.095 0231	7.634 6067	.002 247 191
446	198 916	88 716 536	21.118 7121	7.640 3213	.002 242 152
447	199 809	89 314 623	21.142 3745	7.646 0272	.002 237 136
448	200 704	89 915 392	21.166 0105	7.651 7247	.002 232 143
449	201 601	90 518 849	21.189 6201	7.657 4138	.002 227 171
450	202 500	91 125 000	21.213 2034	7.663 0943	.002 222 222
451	203 401	91 733 851	21.236 7606	7.668 7665	.002 217 295
452	204 304	92 345 408	21.260 2916	7.674 4303	.002 212 389
453	205 209	92 959 677	21.283 7967	7.680 0857	.002 207 506
454	206 116	93 576 664	21.307 2758	7.685 7328	.002 202 643
455	207 025	94 196 375	21.330 7290	7.691 3717	.002 197 802
456	207 936	94 818 816	21.354 1565	7.697 0023	.002 192 982
457	208 849	95 443 993	21.377 5583	7.702 6246	.002 188 184
458	209 764	96 071 912	21.400 9346	7.708 2388	.002 183 406
459	210 681	96 702 579	21.424 2853	7.718 8448	.002 178 649
460	211 600	97 336 000	21.447 6106	7.719 4426	.002 173 913
461	212 521	97 972 181	21.470 9106	7.725 0325	.002 169 197
462	213 444	98 611 128	21.494 1853	7.730 6141	.002 164 502
463	214 369	99 252 847	21.517 4348	7.736 1877	.002 159 827
464	215 296	99 897 344	21.540 6592	7.741 7532	.002 155 172
465	216 225	100 544 625	21.563 8587	7.747 3109	.002 150 538
466	*217 156*	*101 194 696*	21.587 0331	7.752 8606	.002 145 923
467	*218 089*	*101 847 563*	21.610 1828	7.758 4023	.002 141 328
468	*219 024*	*102 503 232*	21.633 3077	7.763 9361	.002 136 752

Number.	Squares.	Cubes.	$\sqrt{}$ Roots.	$\sqrt[3]{}$ Roots.	Reciprocals.
469	219 961	103 161 709	21.656 4078	7.769 4620	.002 132 196
470	220 900	103 823 000	21.679 4834	7.774 9801	.002 127 660
471	221 841	104 487 111	21.702 5344	7.780 4904	.002 123 142
472	222 784	105 154 048	21.725 5610	7.785 9928	.002 118 644
473	223 729	105 828 817	21.748 5632	7.791 4875	.002 114 165
474	224 676	106 496 424	21.771 5411	7.796 9745	.002 109 705
475	225 625	107 171 875	21.794 4947	7.802 4538	.002 105 263
476	226 576	107 850 176	21.817 4242	7.807 9254	.002 100 840
477	227 529	108 531 333	21.840 3297	7.813 3892	.002 096 436
478	228 484	109 215 352	21.863 2111	7.818 8456	.002 092 050
479	229 441	109 902 239	21.886 0686	7.824 2942	.002 087 683
480	230 400	110 592 000	21.908 9023	7.829 7353	.002 083 333
481	231 361	111 284 641	21.931 7122	7.835 1688	.002 079 002
482	232 324	111 980 168	21.954 4984	7.840 5949	.002 074 689
483	233 289	112 678 587	21.977 2610	7.846 0134	.002 070 393
484	234 256	113 379 904	22.000 0000	7.851 4244	.002 066 116
485	235 225	114 084 125	22.022 7155	7.856 8281	.002 061 856
486	236 196	114 791 256	22.045 4077	7.862 2242	.002 057 613
487	237 169	115 501 303	22.068 0765	7.867 6130	.002 053 388
488	238 144	116 214 272	22.090 7220	7.872 9944	.002 049 180
489	239 121	116 930 169	22.113 3444	7.878 3684	.002 044 990
490	240 100	117 649 000	22.135 9436	7.883 7352	.002 040 816
491	241 081	118 370 771	22.158 5198	7.889 0946	.002 036 660
492	242 064	119 095 488	22.181 0730	7.894 4468	.002 032 520
493	243 049	119 823 157	22.203 6033	7.899 7917	.002 028 398
494	244 036	120 553 784	22.226 1108	7.905 1294	.002 024 291
495	245 025	121 287 375	22.248 5955	7.910 4599	.002 020 202
496	246 016	122 023 936	22.271 0575	7.915 7832	.002 016 129
497	247 009	122 763 473	22.293 4968	7.921 0994	.002 012 072
498	248 004	123 505 992	22.315 9136	7.926 4085	.002 008 032
499	249 001	124 251 499	22.338 3079	7.931 7104	.002 004 008
500	250 000	125 000 000	22.360 6798	7.937 0053	.002 000 000
501	251 001	125 751 501	22.383 0293	7.942 2931	.001 996 008
502	252 004	126 506 008	22.405 3565	7.947 5739	.001 992 032
503	253 009	127 263 527	22.427 6615	7.952 8477	.001 988 072
504	254 016	128 024 064	22.449 9443	7.958 1144	.001 984 127
505	255 025	128 787 625	22.472 2051	7.963 3743	.001 980 198
506	256 036	129 554 216	22.494 4438	7.968 6271	.001 976 285
507	257 049	130 323 843	22.516 6605	7.973 8731	.001 972 387
508	258 064	131 096 512	22.538 8553	7.979 1122	.001 968 504
509	259 081	131 872 229	22.561 0283	7.984 3444	.001 964 637
510	260 100	132 651 000	22.583 1796	7.989 5697	.001 960 784
511	261 121	133 432 831	22.605 3091	7.994 7883	.001 956 947
512	262 144	134 217 728	22.627 4170	8.000 0000	.001 953 125
513	263 169	135 005 697	22.649 5033	8.005 2049	.001 949 318
514	264 196	135 796 744	22.671 5681	8.010 4032	.001 945 525
515	265 225	136 590 875	22.693 6114	8.015 5946	.001 941 748
516	266 256	137 388 096	22.715 6334	8.020 7794	.001 937 984
517	267 289	138 188 413	22.737 6341	8.025 9574	.001 934 236
518	268 324	138 991 832	22.759 6134	8.031 1287	.001 930 502
519	269 361	139 798 359	22.781 5715	8.036 2935	.001 926 782
520	270 400	140 608 000	22.803 5085	8.041 4515	.001 923 077

Number.	Squares.	Cubes.	$\sqrt{\ }$ Roots.	$\sqrt[3]{\ }$ Roots.	Reciprocals.
521	271 441	141 420 761	22.825 4241	8.046 6030	.001 919 386
522	272 484	142 236 648	22.847 3193	8.051 7479	.001 915 709
523	273 529	143 055 667	22.869 1933	8.056 8862	.001 912 046
524	274 576	143 877 824	22.891 0463	8.062 0180	.001 908 397
525	275 625	144 703 125	22.912 8785	8.067 1432	.001 904 762
526	276 676	145 531 576	22.934 6899	8.072 2620	.001 901 141
527	277 729	146 363 183	22.956 4806	8.077 3743	.001 897 533
528	278 784	147 197 952	22.978 2506	8.082 4800	.001 893 939
529	279 841	148 035 889	23.000 0000	8.087 5794	.001 890 359
530	280 900	148 877 001	23.021 7289	8.092 6723	.001 886 792
531	281 961	149 721 291	23.043 4372	8.097 7589	.001 883 239
532	283 024	150 568 768	23.065 1252	8.102 8390	.001 879 699
533	284 089	151 419 437	23.086 7928	8.107 9128	.001 876 173
534	285 156	152 273 304	23.108 4400	8.112 9803	.001 872 659
535	286 225	153 130 375	23.130 0670	8.118 0414	.001 869 159
536	287 296	153 990 656	23.151 6738	8.123 0962	.001 865 672
537	288 369	154 854 153	23.173 2605	8.128 1447	.001 862 197
538	289 444	155 720 872	23.194 8270	8.133 1870	.001 858 736
539	290 521	156 590 819	23.216 3735	8.138 2230	.001 855 288
540	291 600	157 464 000	23.237 9001	8.143 2529	.001 851 852
541	292 681	158 340 421	23.259 4067	8.148 2765	.001 848 429
542	293 764	159 220 088	23.280 8935	8.153 2939	.001 845 018
543	294 849	160 103 007	23.302 3604	8.158 3051	.001 841 621
544	295 936	160 989 184	23.323 8076	8.163 3102	.001 838 235
545	297 025	161 878 625	23.345 2351	8.168 3092	.001 834 862
546	298 116	162 771 336	23.366 6429	8.173 3020	.001 831 502
547	299 209	163 667 323	23.388 0311	8.178 2888	.001 828 154
548	300 304	164 566 592	23.409 3998	8.183 2695	.001 824 818
549	301 401	165 469 149	23.430 7490	8.188 2441	.001 821 494
550	302 500	166 375 000	23.452 0788	8.193 2127	.001 818 182
551	[redacted]	167 284 151	23.473 3892	8.198 1753	.001 814 882
552	304 704	168 196 608	23.494 6802	8.203 1319	.001 811 594
553	305 809	169 112 377	23.515 9520	8.208 0825	.001 808 318
554	306 916	170 031 464	23.537 2046	8.213 0271	.001 805 054
555	308 025	170 953 875	23.558 4380	8.217 9657	.001 801 802
556	309 136	171 879 616	23.579 6522	8.222 8985	.001 798 561
557	310 249	172 808 693	23.600 8474	8.227 8254	.001 795 332
558	311 364	173 741 112	23.622 0236	8.232 7463	.001 792 115
559	312 481	174 676 879	23.643 1808	8.237 6614	.001 788 909
560	313 600	175 616 000	23.664 3191	8.242 5706	.001 785 714
561	314 721	176 558 481	23.685 4386	8.247 4740	.001 782 531
562	315 844	177 504 328	23.706 5392	8.252 3715	.001 779 359
[redacted]	316 969	178 453 547	23.727 6210	8.257 2635	.001 776 199
564	318 096	179 406 144	23.748 6842	8.262 1492	.001 773 050
565	319 225	180 362 125	23.769 7286	8.267 0294	.001 769 912
566	320 356	181 321 496	23.790 7545	8.271 9039	.001 766 784
[redacted]	321 489	182 284 263	23.811 7618	8.276 7726	.001 763 668
568	322 624	183 250 432	23.832 7506	8.281 6255	.001 760 563
569	323 761	184 220 009	23.853 7209	8.286 4928	.001 757 469
570	324 900	185 193 000	23.874 6728	8.291 3444	.001 754 386
571	326 041	186 169 411	23.895 6063	8.296 1903	.001 751 313
572	327 184	187 149 248	23.9164215	8.301 0304	.001 748 252

Number.	Squares.	Cubes.	$\sqrt{\ }$ Roots.	$\sqrt[3]{\ }$ Roots.	Reciprocals.
573	328 329	188 132 517	23.937 4184	8.305 8651	.001 745 201
574	329 476	189 119 224	23.958 2971	8.310 6941	.001 742 160
575	330 625	190 109 375	23.979 1576	8.315 5175	.001 739 130
576	331 776	191 102 976	24.000 0000	8.320 3353	.001 736 111
577	332 927	192 100 033	24.020 8243	8.325 1475	.001 733 102
578	334 084	193 100 552	24.041 6306	8.329 9542	.001 730 104
579	335 241	194 104 539	24.062 4188	8.334 7553	.001 727 116
580	336 400	195 112 000	24.083 1891	8.339 5509	.001 724 138
581	337 561	196 122 941	24.103 9416	8.344 3410	.001 721 170
582	338 724	197 137 368	24.124 6762	8.349 1256	.001 718 213
583	339 889	198 155 287	24.145 3929	8.353 9047	.001 715 266
584	341 056	199 176 704	24.166 0919	8.358 6784	.001 712 329
585	342 225	200 201 625	24.186 7732	8.363 4466	.001 709 402
586	343 396	201 230 056	24.207 4369	8.368 2095	.001 706 485
587	344 569	202 262 003	24.228 0829	8.372 9668	.001 703 578
588	345 744	203 297 472	24.248 7113	8.377 7188	.001 700 680
589	346 921	204 336 469	24.269 3222	8.382 4653	.001 697 793
590	348 100	205 379 000	24.289 9156	8.387 2065	.001 694 915
591	349 281	206 425 071	24.310 4996	8.391 9428	.001 692 047
592	350 464	207 474 688	24.331 0501	8.396 6729	.001 689 189
593	351 649	208 527 857	24.351 5913	8.401 3981	.001 686 341
594	352 836	209 584 584	24.372 1152	8.406 1180	.001 683 502
595	354 025	210 644 875	24.392 6218	8.410 8326	.001 680 672
596	355 216	211 708 736	24.413 1112	8.415 5419	.001 677 852
597	356 409	212 776 173	24.433 5834	8.420 2460	.001 675 042
598	357 604	213 847 192	24.454 0385	8.424 9448	.001 672 241
599	358 801	214 921 799	24.474 4765	8.429 6383	.001 669 449
600	360 000	216 000 000	24.494 8974	8.434 3267	.001 666 667
601	361 201	217 081 801	24.515 3013	8.439 0098	.001 663 894
602	362 404	218 167 208	24.535 6883	8.443 6877	.001 661 130
603	363 609	219 256 227	24.556 0583	8.448 3605	.001 658 375
604	364 816	220 348 864	24.576 4115	8.453 0281	.001 655 629
605	366 025	221 445 125	24.596 7478	8.457 6906	.001 652 893
606	367 236	222 545 016	24.617 0673	8.462 3479	.001 650 165
607	368 449	223 648 543	24.637 3700	8.467 0001	.001 647 446
608	369 664	224 755 712	24.657 6560	8.471 6471	.001 644 737
609	370 881	225 866 529	24.677 9254	8.476 2892	.001 642 036
610	372 100	226 981 000	24.698 1781	8.480 9261	.001 639 344
611	373 321	228 099 131	24.718 4142	8.485 5579	.001 636 661
612	374 544	229 220 928	24.738 6338	8.490 1848	.001 633 987
613	375 769	230 346 397	24.758 8368	8.494 8065	.001 631 321
614	376 996	231 475 544	24.779 0234	8.499 4233	.001 628 664
615	378 225	232 608 375	24.799 1935	8.504 0350	.001 626 016
616	379 456	233 744 896	24.819 3473	8.508 6417	.001 623 377
617	380 689	234 885 113	24.839 4847	8.513 2435	.001 620 746
618	381 924	236 029 032	24.859 6058	8.517 8403	.001 618 123
619	383 161	237 176 659	24.879 7106	8.522 4331	.001 615 509
620	384 400	238 328 000	24.899 7992	8.527 0189	.001 612 903
621	385 641	239 483 061	24.919 8716	8.531 6009	.001 610 306
622	386 884	240 641 848	24.939 9278	8.536 1780	.001 607 717
623	388 129	241 804 367	24.959 9679	8.540 7501	.001 605 136
624	389 376	242 970 624	24.979 9920	8.545 3173	.001 602 564

Number.	Squares.	Cubes.	√ Roots.	∛ Roots.	Reciprocals.
625	390 625	244 140 625	25.000 0000	8.549 8797	.001 600 000
626	391 876	245 134 376	25.019 9920	8.554 4372	.001 597 444
627	393 129	246 491 883	25.039 9681	8.558 9899	.001 594 896
628	394 384	247 673 152	25.059 9282	8.563 5377	.001 592 357
629	395 641	248 858 189	25.079 8724	8.568 0807	.001 589 825
630	396 900	250 047 000	25.099 8008	8.572 6189	.001 587 302
631	398 161	251 239 591	25.119 7134	8.577 1523	.001 584 786
632	399 424	252 435 968	25.139 6102	8.581 6809	.001 582 278
633	400 689	253 636 137	25.159 4913	8.586 2247	.001 579 779
634	401 956	254 840 104	25.179 3566	8.590 7238	.001 577 287
635	403 225	256 047 875	25.199 2063	8.595 2380	.001 574 803
636	404 496	257 259 456	25.219 0404	8.599 7476	.001 572 327
637	405 769	258 474 853	25.238 8589	8.604 2525	.001 569 859
638	407 044	259 694 072	25.258 6619	8.608 7526	.001 567 398
639	408 321	260 917 119	25.278 4493	8.613 2480	.001 564 945
640	409 600	262 144 000	25.298 2213	8.617 7388	.001 562 500
641	410 881	263 374 721	25.317 9778	8.622 2248	.001 560 062
642	412 164	264 609 288	25.337 7189	8.626 7063	.001 557 632
643	413 449	265 847 707	25.357 4447	8.631 1830	.001 555 210
644	414 736	267 089 984	25.377 1551	8.635 6551	.001 552 795
645	416 025	268 336 125	25.396 8502	8.640 1226	.001 550 388
646	417 316	269 585 136	25.416 5302	8.644 5855	.001 547 988
647	418 609	270 840 023	25.436 1947	8.649 0437	.001 545 595
648	419 904	272 097 792	25.455 8441	8.653 4974	.001 543 210
649	421 201	273 359 449	25.475 4784	8.657 9465	.001 540 832
650	422 500	274 625 000	25.495 0976	8.662 3911	.001 538 462
651	423 801	275 894 451	25.514 7013	8.666 8310	.001 536 098
652	425 104	277 167 808	25.534 2907	8.671 2665	.001 533 742
653	426 409	278 445 077	25.553 8647	8.675 6974	.001 531 394
654	427 716	279 726 264	25.573 4237	8.680 1237	.001 529 052
655	429 025	281 011 375	25.592 9678	8.684 5456	.001 526 718
656	430 336	282 300 416	25.612 4969	8.688 9630	.001 524 390
657	431 649	283 593 393	25.632 0112	8.693 3759	.001 522 070
658	432 964	284 890 312	25.651 5107	8.697 7843	.001 519 757
659	434 281	286 191 179	25.670 9953	8.702 1882	.001 517 451
660	435 600	287 496 000	25.690 4652	8.706 5877	.001 515 152
661	436 921	288 804 781	25.709 9203	8.710 9827	.001 512 859
662	438 244	290 117 528	25.729 3607	8.715 3734	.001 510 574
663	439 569	291 434 247	25.748 7864	8.719 7596	.001 508 296
664	440 896	292 754 944	25.768 1975	8.724 1414	.001 506 024
665	442 225	294 079 625	25.787 5939	8.728 5187	.001 503 759
666	443 556	295 408 296	25.806 9758	8.732 8918	.001 501 502
667	444 889	296 740 963	25.826 3431	8.737 2604	.001 499 250
668	446 224	298 077 632	25.845 6960	8.741 6246	.001 497 006
669	447 561	299 418 309	25.865 0343	8.745 9846	.001 494 768
670	448 900	300 763 000	25.884 3582	8.750 3401	.001 492 537
671	450 241	302 111 711	25.903 6677	8.754 6913	.001 490 313
672	451 584	303 464 448	25.922 9628	8.759 0383	.001 488 095
673	452 929	304 821 217	25.942 2435	8.763 3809	.001 485 884
674	454 276	306 182 024	25.961 5100	8.767 7192	.001 483 680
675	455 625	307 546 875	25.980 7621	8.772 0532	.001 481 481
676	456 976	308 915 776	26.000 0000	8.776 3830	.001 479 290

Number.	Squares.	Cubes.	$\sqrt{}$ Roots.	$\sqrt[3]{}$ Roots.	Reciprocals.
677	458 329	310 288 733	26.019 2237	8.780 7084	.001 477 105
678	459 684	311 665 752	26.038 4331	8.785 0296	.001 474 926
679	461 041	313 046 839	26.057 6284	8.789 3466	.001 472 754
680	462 400	314 432 000	26.076 8096	8.793 6593	.001 470 588
681	463 761	315 821 241	26.095 9767	8.797 9679	.001 468 429
682	465 124	317 214 568	26.115 1297	8.802 2721	.001 466 276
683	466 489	318 611 987	26.134 2687	8.806 5722	.001 464 129
684	467 856	320 013 504	26.153 3937	8.810 8681	.001 461 988
685	469 225	321 419 125	26.172 5047	8.815 1598	.001 459 854
686	470 596	322 828 856	26.191 6017	8.819 4474	.001 457 726
687	471 969	324 242 703	26.210 6848	8.823 7307	.001 455 604
688	473 344	325 660 672	26.229 7541	8.828 0099	.001 453 488
689	474 721	327 082 769	26.248 8095	8.832 2850	.001 451 379
690	476 100	328 509 000	26.267 8511	8.836 5559	.001 449 275
691	477 481	329 939 371	26.286 8789	8.840 8227	.001 447 178
692	478 864	331 373 888	26.305 8929	8.845 0854	.001 445 087
693	480 249	332 812 557	26.324 8932	8.849 3440	.001 443 001
694	481 636	334 255 384	26.343 8797	8.853 5985	.001 440 922
695	483 025	335 702 375	26.362 8527	8.857 8489	.001 438 849
696	484 416	337 153 536	26.381 8119	8.862 0952	.001 436 782
697	485 809	338 608 873	26.400 7576	8.866 3375	.001 434 720
698	487 204	340 068 392	26.419 6896	8.870 5757	.001 432 665
699	488 601	341 532 099	26.438 6081	8.874 8099	.001 430 615
700	490 000	343 000 000	26.457 5131	8.879 0400	.001 428 571
701	491 401	344 472 101	26.476 4046	8.883 2661	.001 426 534
702	492 804	345 948 408	26.495 2826	8.887 4882	.001 424 501
703	494 209	347 428 927	26.514 1472	8.891 7063	.001 422 475
704	495 616	348 913 664	26.532 9983	8.895 9204	.001 420 455
705	497 025	350 402 625	26.551 8361	8.900 1304	.001 418 440
706	498 436	351 895 816	26.570 6605	8.904 3366	.001 416 431
707	499 849	353 393 243	26.589 4716	8.908 5387	.001 414 427
708	501 264	354 894 912	26.608 2694	8.912 7369	.001 412 429
709	502 681	356 400 829	26.627 0539	8.916 9311	.001 410 437
710	504 100	357 911 000	26.645 8252	8.921 1214	.001 408 451
711	505 521	359 425 431	26.664 5833	8.925 3078	.001 406 470
712	506 944	360 944 128	26.683 3281	8.929 4902	.001 404 494
713	508 369	362 467 097	26.702 0598	8.933 6687	.001 402 525
714	509 796	363 994 344	26.720 7784	8.937 8433	.001 400 560
715	511 225	365 525 875	26.739 4839	8.942 0140	.001 398 601
716	512 656	367 061 696	26.758 1763	8.946 1809	.001 396 648
717	514 089	368 601 813	26.776 8557	8.950 3438	.001 394 700
718	515 524	370 146 232	26.795 5220	8.954 5029	.001 392 758
719	516 961	371 694 959	26.814 1754	8.958 6581	.001 390 821
720	518 400	373 248 000	26.832 8157	8.962 8095	.001 388 889
721	519 841	374 805 361	26.851 4432	8.966 9570	.001 386 963
722	521 284	376 367 048	26.870 0577	8.971 1007	.001 385 042
723	522 729	377 933 067	26.888 6593	8.975 2406	.001 383 126
724	524 176	379 503 424	26.907 2481	8.979 3766	.001 381 215
725	525 625	381 078 125	26.925 8240	8.983 5089	.001 379 310
726	527 076	382 657 176	26.944 3872	8.987 6373	.001 377 410
727	528 529	384 240 583	26.962 9375	8.991 7620	.001 375 516
728	529 984	385 828 352	26.981 4751	8.995 8899	.001 373 [illegible]

Number.	Squares.	Cubes.	$\sqrt{}$ Roots.	$\sqrt[3]{}$ Roots.	Reciprocals.
729	531 441	387 420 489	27.000 0000	9.000 0000	.001 371 742
730	532 900	389 017 000	27.018 5122	9.004 1134	.001 369 863
731	534 361	390 617 891	27.037 0117	9.008 2229	.001 367 989
732	535 824	392 223 168	27.055 4985	9.012 3288	.001 366 120
733	537 289	393 832 837	27.073 9727	9.016 4309	.001 364 256
734	538 756	395 446 904	27.092 4344	9.020 5293	.001 362 398
735	540 225	397 065 375	27.110 8834	9.024 6239	.001 360 544
736	541 696	398 688 256	27.129 3199	9.028 7149	.001 358 696
737	543 169	400 315 553	27.147 7149	9.032 8021	.001 356 852
738	544 644	401 947 272	27.166 1554	9.036 8857	.001 355 014
739	546 121	403 583 419	27.184 5544	9.040 9655	.001 353 180
740	547 600	405 224 000	27.202 9140	9.045 0419	.001 351 351
741	549 081	406 869 021	27.221 3152	9.049 1142	.001 349 528
742	550 564	408 518 488	27.239 6769	9.053 1831	.001 347 709
743	552 049	410 172 407	27.258 0263	9.057 2482	.001 345 895
744	553 536	411 830 784	27.276 3634	9.061 3098	.001 344 086
745	555 025	413 493 625	27.294 6881	9.065 3677	.001 342 282
746	556 516	415 160 936	27.313 0006	9.069 4220	.001 340 483
747	558 009	416 832 723	27.331 3007	9.073 4726	.001 338 688
748	559 504	418 508 992	27.349 5887	9.077 5197	.001 336 898
749	561 001	420 189 749	27.367 8644	9.081 5631	.001 335 113
750	562 500	421 875 000	27.386 1279	9.085 6030	.001 333 333
751	564 001	423 564 751	27.404 3792	9.089 6352	.001 331 558
752	565 504	425 259 008	27.422 6184	9.093 6719	.001 329 787
753	567 009	426 957 777	27.440 8455	9.097 7010	.001 328 021
754	568 516	428 661 064	27.459 0604	9.101 7265	.001 326 260
755	570 025	430 368 875	27.477 2633	9.105 7485	.001 324 503
756	571 536	432 081 216	27.495 4542	9.109 7669	.001 322 751
757	573 049	433 798 093	27.513 6330	9.113 7818	.001 321 004
758	574 564	435 519 512	27.531 7998	9.117 7931	.001 319 261
759	576 081	437 245 479	27.549 9546	9.121 8010	.001 317 523
760	577 600	438 976 000	27.568 0975	9.125 8053	.001 315 789
761	579 121	440 711 081	27.586 2284	9.129 8061	.001 314 060
762	580 644	442 450 728	27.604 3475	9.133 8034	.001 312 336
763	582 169	444 194 947	27.622 4546	9.137 7971	.001 310 616
764	583 696	445 943 744	27.640 5499	9.141 7874	.001 308 901
765	585 225	447 697 125	27.658 6334	9.145 7742	.001 307 190
766	586 756	449 455 096	27.676 7050	9.149 7576	.001 305 483
767	588 289	451 217 663	27.694 7648	9.153 7375	.001 303 781
768	589 824	452 984 832	27.712 8129	9.157 7139	.001 302 083
769	591 361	454 756 609	27.730 8492	9.161 6869	.001 300 390
770	592 900	456 533 000	27.748 8739	9.165 6565	.001 298 701
771	594 441	458 314 011	27.766 8868	9.169 6225	.001 297 017
772	595 984	460 099 648	27.784 8880	9.173 5852	.001 295 337
773	597 529	461 889 917	27.802 8775	9.177 5445	.001 293 661
774	599 076	463 684 824	27.820 8555	9.181 5003	.001 291 990
775	600 625	465 484 375	27.838 8218	9.185 4527	.001 290 323
776	602 176	467 288 576	27.856 7766	9.189 4018	.001 288 660
777	603 729	469 097 433	27.874 7197	9.193 3474	.001 287 001
778	605 284	470 910 952	27.892 6514	9.197 2897	.001 285 347
779	606 841	472 729 139	27.910 5715	9.201 2286	.001 283 697
780	608 400	474 552 000	27.928 4801	9.205 1641	.001 282 051

Number.	Squares.	Cubes.	$\sqrt{}$ Roots.	$\sqrt[3]{}$ Roots.	Reciprocals.
781	609 961	476 379 541	27.946 3772	9.209 0962	.001 280 410
782	611 524	478 211 768	27.964 2629	9.213 0250	.001 278 772
783	613 089	480 048 687	27.982 1372	9.216 9505	.001 277 139
784	614 656	481 890 304	28.000 0000	9.220 8726	.001 275 510
785	616 225	483 736 625	28.017 8515	9.224 7914	.001 273 885
786	617 796	485 587 656	28.035 6915	9.228 7068	.001 272 265
787	619 369	487 443 403	28.053 5203	9.232 6189	.001 270 648
788	620 944	489 303 872	28.071 3377	9.236 5277	.001 269 036
789	622 521	491 169 069	28.089 1438	9.240 4333	.001 267 427
790	624 100	493 039 000	28.106 9386	9.244 3355	.001 265 823
791	625 681	494 913 671	28.124 7222	9.248 2344	.001 264 223
792	627 264	496 793 088	28.142 4946	9.252 1300	.001 262 626
793	628 849	498 677 257	28.160 2557	9.256 0224	.001 261 034
794	630 436	500 566 184	28.178 0056	9.259 9114	.001 259 446
795	632 025	502 459 875	28.195 7444	9.263 7973	.001 257 862
796	633 616	504 358 336	28.213 4720	9.267 6798	.001 256 281
797	635 209	506 261 573	28.231 1884	9.271 5592	.001 254 705
798	636 804	508 169 592	28.248 8938	9.275 4352	.001 253 133
799	638 401	510 082 399	28.266 5881	9.279 3081	.001 251 564
800	640 000	512 000 000	28.284 2712	9.283 1777	.001 250 000
801	641 601	513 922 401	28.301 9434	9.287 0444	.001 248 439
802	643 204	515 849 608	28.319 6045	9.290 9072	.001 246 883
803	644 809	517 781 627	28.337 2546	9.294 7671	.001 245 330
804	646 416	519 718 464	28.354 8938	9.298 6239	.001 243 781
805	648 025	521 660 125	28.372 5219	9.302 4775	.001 242 236
806	649 636	523 606 616	28.390 1391	9.306 3278	.001 240 695
807	651 249	525 557 943	28.407 7454	9.310 1750	.001 239 157
808	652 864	527 514 112	28.425 3408	9.314 0190	.001 237 624
809	654 481	529 475 129	28.442 9253	9.317 8599	.001 236 094
810	656 100	531 441 000	28.460 4989	9.321 6975	.001 234 568
811	657 721	533 411 731	28.478 0617	9.325 5320	.001 233 046
812	659 344	535 387 328	28.495 6137	9.329 3634	.001 231 527
813	660 969	537 367 797	28.513 1549	9.333 1916	.001 230 012
814	662 596	539 353 144	28.530 6852	9.337 0167	.001 228 501
815	664 225	541 343 375	28.548 2048	9.340 8386	.001 226 994
816	665 856	543 338 496	28.565 7137	9.344 6575	.001 225 499
817	667 489	545 338 513	28.583 2119	9.348 4731	.001 223 990
818	669 124	547 343 432	28.600 6993	9.352 2857	.001 222 494
819	670 761	549 353 259	28.618 1760	9.356 0952	.001 221 001
820	672 400	551 368 000	28.635 6421	9.359 9016	.001 219 512
821	674 041	553 387 661	28.653 0976	9.363 7049	.001 218 027
822	675 684	555 412 248	28.670 5424	9.367 5051	.001 216 545
823	677 329	557 441 767	28.687 9716	9.371 3022	.001 215 067
824	678 976	559 476 224	28.705 4002	9.375 0963	.001 213 592
825	680 625	561 515 625	28.722 8132	9.378 8873	.001 212 121
826	682 276	563 559 976	28.740 2157	9.382 6752	.001 210 654
827	683 929	565 609 283	28.757 6077	9.386 4600	.001 209 190
828	685 584	567 663 552	28.774 9891	9.390 2419	.001 207 729
829	687 241	569 722 789	28.792 3601	9.394 0206	.001 206 273
830	688 900	571 787 000	28.809 7206	9.397 7964	.001 204 819
831	690 561	573 856 191	28.827 0706	9.401 5691	.001 203 369
832	692 224	575 930 368	28.844 4102	9.405 3387	.001 201 9[illegible]

Number	Squares.	Cubes.	√ Roots.	∛ Roots.	Reciprocals.
833	693 889	578 009 537	28.861 7394	9.409 1054	.001 200 480
834	695 556	580 093 704	28.879 0582	9.412 8690	.001 199 041
835	697 225	582 182 875	28.896 3666	9.416 6297	.001 197 605
836	698 896	584 277 056	28.913 6646	9.420 3873	.001 196 172
837	700 569	586 376 253	28.930 9523	9.424 1420	.001 194 743
838	702 244	588 480 472	28.948 2297	9.427 8936	.001 193 317
839	703 921	590 589 719	28.965 4967	9.431 6423	.001 191 895
840	705 600	592 704 000	28.982 7535	9.435 3800	.001 190 476
841	707 281	594 823 321	29.000 0000	9.439 1307	.001 189 061
842	708 964	596 947 688	29.017 2363	9.442 8704	.001 187 648
[redacted]	710 649	599 077 107	29.034 4623	9.446 6072	.001 186 240
844	712 336	601 211 584	29.051 6781	9.450 3410	.001 184 834
845	714 025	603 351 125	29.068 8837	9.454 0719	.001 183 432
846	715 716	605 495 736	29.086 0791	9.457 7999	.001 182 033
847	717 409	607 645 423	29.103 2644	9.461 5249	.001 180 638
848	719 104	609 800 192	29.120 4396	9.465 2470	.001 179 245
849	720 801	611 960 049	29.137 6046	9.468 9661	.001 177 856
850	722 500	614 125 000	29.154 7595	9.472 6824	.001 176 471
851	724 201	616 295 051	29.171 9043	9.476 3957	.001 175 088
852	725 904	618 470 208	29.189 0390	9.480 1061	.001 173 709
853	727 609	620 650 477	29.206 1637	9.483 8136	.001 172 333
854	729 316	622 835 864	29.223 2784	9.487 5182	.001 170 960
855	731 025	625 026 375	29.240 3830	9.491 2200	.001 169 591
856	732 736	627 222 016	29.257 4777	9.494 9188	.001 168 224
857	734 449	629 422 793	29.274 5623	9.498 6147	.001 166 861
858	736 164	631 628 712	29.291 6370	9.502 3078	.001 165 501
859	737 881	633 839 779	29.308 7018	9.505 9980	.001 164 144
860	739 600	636 056 000	29.325 7566	9.509 6854	.001 162 791
861	741 321	638 277 381	29.342 8015	9.513 3699	.001 161 440
862	743 044	640 503 928	29.359 8365	9.517 0515	.001 160 093
863	744 769	642 735 647	29.376 8616	9.520 7303	.001 158 749
864	746 496	644 972 544	29.393 8769	9.524 4063	.001 157 407
865	748 225	647 214 625	29.410 8823	9.528 0794	.001 156 069
866	749 956	649 461 896	29.427 8779	9.531 7497	.001 154 734
867	751 689	651 714 363	29.444 8637	9.535 4172	.001 153 403
868	753 424	653 972 032	29.461 8397	9.539 0818	.001 152 074
869	755 161	656 234 909	29.478 8059	9.542 7437	.001 150 748
870	756 900	658 503 000	29.495 7624	9.546 4027	.001 149 425
871	758 641	660 776 311	29.512 7091	9.550 0589	.001 148 106
872	760 384	663 054 848	29.529 6461	9.553 7123	.001 146 789
873	762 129	665 338 617	29.546 5734	9.557 3630	.001 145 475
874	763 876	667 627 624	29.563 4910	9.561 0108	.001 144 165
875	765 625	669 921 875	29.580 3989	9.564 6559	.001 142 857
876	767 376	672 221 376	29.597 2972	9.568 2782	.001 141 553
877	769 129	674 526 133	29.614 1858	9.571 9377	.001 140 251
878	770 884	676 836 152	29.631 0648	9.575 5745	.001 138 952
879	772 641	679 151 439	29.647 9342	9.579 2085	.001 137 656
880	774 400	681 472 000	29.664 7939	9.582 8397	.001 136 364
881	776 161	683 797 841	29.681 6442	9.586 4682	.001 135 074
882	777 924	686 128 968	29.698 4848	9.590 0937	.001 133 787
883	779 689	688 465 387	29.715 3159	9.593 7169	.001 132 503
884	781 456	690 807 104	29.732 1375	9.597 3373	.001 131 222

Number.	Squares.	Cubes.	$\sqrt{}$ Roots.	$\sqrt[3]{}$ Roots.	Reciprocals.
885	783 225	693 154 125	29.748 9496	9.600 9548	.001 129 944
886	784 996	695 506 456	29.765 7521	9.604 5696	.001 128 668
887	786 769	697 864 103	29.782 5452	9.608 1817	.001 127 396
888	788 544	700 227 072	29.799 3289	9.611 7911	.001 126 126
889	790 321	702 595 369	29.816 1030	9.615 3977	.001 124 859
890	792 100	704 969 000	29.832 8678	9.619 0017	.001 123 596
891	793 881	707 347 971	29.849 6231	9.622 6030	.001 122 334
892	795 664	707 932 288	29.866 3690	9.626 2016	.001 121 076
893	797 449	712 121 957	29.883 1056	9.629 7975	.001 119 821
894	799 236	714 516 984	29.899 8328	9.633 3907	.001 118 568
895	801 025	716 917 375	29.916 5506	9.636 9812	.001 117 818
896	802 816	719 323 136	29.933 2591	9.640 5690	.001 116 071
897	804 609	721 734 273	29.949 9583	9.644 1542	.001 114 827
898	806 404	724 150 792	29.966 6481	9.647 7367	.001 113 586
899	808 201	726 572 699	29.983 3287	9.651 3166	.001 112 347
900	810 000	729 000 000	30.000 0000	9.654 8938	.001 111 111
901	811 801	731 432 701	30.016 6621	9.658 4684	.001 109 878
902	813 604	733 870 808	30.033 3148	9.662 0403	.001 108 647
903	815 409	736 314 327	30.049 9584	9.665 6096	.001 107 420
904	817 216	738 763 264	30.066 5928	9.669 1762	.001 106 195
905	819 025	741 217 625	30.083 2179	9.672 7403	.001 104 972
906	820 836	743 677 416	30.099 8339	9.676 3017	.001 103 753
907	822 649	746 142 643	30.116 4407	9.679 8604	.001 102 536
908	824 464	748 613 312	30.133 0383	9.683 4166	.001 101 322
909	826 281	751 089 429	30.149 6269	9.686 9701	.001 100 110
910	828 100	753 571 000	30.166 2063	9.690 5211	.001 098 901
911	829 921	756 058 031	30.182 7765	9.694 0694	.001 097 695
912	831 744	758 550 828	30.199 3377	9.697 6151	.001 096 491
913	833 569	761 048 497	30.215 8899	9.701 1583	.001 095 290
914	835 396	763 551 944	30.232 4329	9.704 6989	.001 094 092
915	837 225	766 060 875	30.248 9669	9.708 2369	.001 092 896
916	839 056	768 575 296	30.265 4919	9.711 7723	.001 091 703
917	840 889	771 095 213	30.282 0079	9.715 3051	.001 090 513
918	842 724	773 620 632	30.298 5148	9.718 8354	.001 089 325
919	844 561	776 151 559	30.315 0128	9.722 3631	.001 088 139
920	846 400	778 688 000	30.331 5018	9.725 8883	.001 086 957
921	848 241	781 229 961	30.347 9818	9.729 4109	.001 085 776
922	850 084	783 777 448	30.364 4529	9.732 9309	.001 084 599
923	851 929	786 330 467	30.380 9151	9.736 4484	.001 083 423
924	853 776	788 889 024	30.397 3683	9.739 9634	.001 082 251
925	855 625	791 453 125	30.413 8127	9.743 4758	.001 081 081
926	857 476	794 022 776	30.430 2481	9.746 9857	.001 079 914
927	859 329	796 597 983	30.446 6747	9.750 4930	.001 078 749
928	861 184	799 178 752	30.463 0924	9.753 9979	.001 077 586
929	863 041	801 765 089	30.479 5013	9.757 5002	.001 076 426
930	864 900	804 357 000	30.495 9014	9.761 0001	.001 075 269
931	866 761	806 954 491	30.512 2926	9.764 4974	.001 074 114
932	868 624	809 557 568	30.528 6750	9.767 9922	.001 072 961
933	870 489	812 166 237	30.545 0487	9.771 4845	.001 071 811
934	872 356	814 780 504	30.561 4136	9.774 9743	.001 070 664
935	874 225	817 400 375	30.577 7697	9.778 4616	.001 069 519
936	876 096	820 025 856	30.594 1171	9.781 9466	.001 068 376

Number.	Squares.	Cubes.	$\sqrt{}$ Roots.	$\sqrt[3]{}$ Roots.	Reciprocals.
937	877 969	822 656 953	30.610 4557	9.785 4288	.001 067 236
938	879 844	825 293 672	30.626 7857	9.788 9087	.001 066 098
939	881 721	827 936 019	30.643 1069	9.792 3861	.001 064 963
940	883 600	830 584 000	30.659 4194	9.795 8611	.001 063 830
941	885 481	833 237 621	30.675 7233	9.799 3336	.001 062 699
942	887 364	835 896 888	30.692 0185	9.802 8036	.001 061 571
943	889 249	838 561 807	30.708 3051	9.806 2711	.001 060 445
944	891 136	841 232 384	30.724 5830	9.809 7362	.001 059 322
945	893 025	843 908 625	30.740 8523	9.813 1989	.001 058 201
946	894 916	846 590 536	30.757 1130	9.816 6591	.001 057 082
947	896 809	849 278 123	30.773 3651	9.820 1169	.001 055 966
948	898 704	851 971 392	30.789 6086	9.823 5723	.001 054 852
949	900 601	854 670 349	30.805 8436	9.827 0252	.001 053 741
950	902 500	857 375 000	30.822 0700	9.830 4757	.001 052 632
951	904 401	860 085 351	30.838 2879	9.833 9238	.001 051 525
952	906 304	862 801 408	30.854 4972	9.837 3695	.001 050 420
953	908 209	865 523 177	30.870 6981	9.840 8127	.001 049 318
954	910 116	868 250 664	30.886 8904	9.844 2536	.001 048 218
955	912 025	870 983 875	30.903 0743	9.847 6920	.001 047 120
956	913 936	873 722 816	30.919 2477	9.851 1280	.001 046 025
957	915 849	876 467 493	30.935 4166	9.854 5617	.001 044 932
958	917 764	879 217 912	30.951 5751	9.857 9929	.001 043 841
959	919 681	881 974 079	30.967 7251	9.861 4218	.001 042 753
960	921 600	884 736 000	30.983 8668	9.864 8483	.001 041 667
961	923 521	887 503 681	31.000 0000	9.868 2724	.001 040 583
962	925 444	890 277 128	31.016 1248	9.871 6941	.001 039 501
963	927 369	893 056 347	31.032 2413	9.875 1135	.001 038 422
964	929 296	895 841 344	31.048 3494	9.878 5305	.001 037 344
965	931 225	898 632 125	31.064 4491	9.881 9451	.001 036 269
966	933 156	901 428 696	31.080 5405	9.885 3574	.001 035 197
967	935 089	904 231 063	31.096 6236	9.888 7673	.001 034 126
968	937 024	907 039 232	31.112 6984	9.892 1749	.001 033 058
969	938 961	909 853 209	31.128 7648	9.895 5801	.001 031 992
970	940 900	912 673 000	31.144 8230	9.898 9830	.001 030 928
971	942 841	915 498 611	31.160 8729	9.902 3835	.001 029 866
972	944 784	918 330 048	31.176 9145	9.905 7817	.001 028 807
973	946 729	921 167 317	31.192 9479	9.909 1776	.001 027 749
974	948 676	924 010 424	31.208 9731	9.912 5712	.001 026 694
975	950 625	926 859 375	31.224 9900	9.915 9624	.001 025 641
976	952 576	929 714 176	31.240 9987	9.919 3513	.001 024 590
977	954 529	932 574 833	31.256 9992	9.922 7379	.001 023 541
978	956 484	935 441 352	31.272 9915	9.926 1222	.001 022 495
979	958 441	938 313 739	31.288 9757	9.929 5042	.001 021 450
980	960 400	941 192 000	31.304 9517	9.932 8839	.001 020 408
981	962 361	944 076 141	31.320 9195	9.936 2613	.001 019 168
982	964 324	946 966 168	31.336 8792	9.939 6363	.001 018 330
983	966 289	949 862 087	31.352 8308	9.943 0092	.001 017 294
984	968 256	952 763 904	31.368 7743	9.946 3797	.001 016 260
985	970 225	955 671 625	31.384 7097	9.949 7479	.001 015 228
986	972 196	958 585 256	31.400 6369	9.953 1138	.001 014 199
987	974 169	961 504 803	31.416 5561	9.956 4775	.001 013 171
988	976 144	964 430 272	31.432 4673	9.959 8389	.001 012 1

Number.	Squares.	Cubes.	$\sqrt{}$ Roots.	$\sqrt[3]{}$ Roots.	Reciprocals.
989	978 121	967 361 669	31.448 3704	9.963 1981	.001 011 122
990	980 100	970 299 000	31.464 2654	9.966 5549	.001 010 101
991	982 081	973 242 271	31.480 1525	9.969 9055	.001 009 082
992	984 064	976 191 488	31.496 0315	9.973 2619	.001 008 065
993	986 049	979 146 657	31.511 9025	9.976 6120	.001 007 049
994	988 036	982 107 784	31.527 7655	9.979 9599	.001 006 036
995	990 025	985 074 875	31.543 6206	9.983 3055	.001 005 025
996	992 016	988 047 936	31.559 4677	9.986 6488	.001 004 016
997	994 009	991 026 973	31.575 3068	9.989 9900	.001 003 009
998	996 004	994 011 992	31.591 1380	9.993 3289	.001 002 004
999	998 001	997 002 999	31.606 9613	9.996 6656	.001 001 001
1000	1 000 000	1 000 000 000	31.622 7766	10.000 0000	.001 000 000
1001	1 002 001	1 003 003 001	31.638 5840	10.003 3222	.000 999 0010
1002	1 004 004	1 006 012 008	31.654 3866	10.006 6622	.000 998 0040
1003	1 006 009	1 009 027 027	31.670 1752	10.009 9899	.000 997 0090
1004	1 008 016	1 012 048 064	31.685 9590	10.013 3155	.000 996 0159
1005	1 010 025	1 015 075 125	31.701 7349	10.016 6389	.000 995 0249
1006	1 012 036	1 018 108 216	31.717 5030	10.019 9601	.000 994 0358
1007	1 014 049	1 021 147 343	31.733 2633	10.023 2791	.000 993 0487
1008	1 016 064	1 024 192 512	31.749 0157	10.026 5958	.000 992 0635
1009	1 018 081	1 027 243 729	31.764 7603	10.029 9104	.000 991 0803
1010	1 020 100	1 030 301 000	31.780 4972	10.033 2228	.000 990 0990
1011	1 022 121	1 033 364 331	31.796 2262	10.036 5330	.000 989 1197
1012	1 024 144	1 036 433 728	31.811 9474	10.039 8410	.000 988 1423
1013	1 026 169	1 039 509 197	31.827 6609	10.043 1469	.000 987 1668
1014	1 028 196	1 042 590 744	31.843 3666	10.046 4506	.000 986 1933
1015	1 030 225	1 045 678 375	31.859 0646	10.049 7521	.000 985 2217
1016	1 032 256	1 048 772 096	31.874 7549	10.053 0514	.000 984 2520
1017	1 034 289	1 051 871 913	31.890 4374	10.056 3485	.000 983 2842
1018	1 036 324	1 054 977 832	31.906 1123	10.059 6435	.000 982 3183
1019	1 038 361	1 058 089 859	31.921 7794	10.062 9364	.000 981 3543
1020	1 040 400	1 061 208 000	31.937 4388	10.066 2271	.000 980 3922
1021	1 042 441	1 064 332 261	31.953 0906	10.069 5156	.000 979 4319
1022	1 044 484	1 067 462 648	31.968 7347	10.072 8020	.000 978 4736
1023	1 046 529	1 070 599 167	31.984 3712	10.076 0863	.000 977 5171
1024	1 048 576	1 073 741 824	32.000 0000	10.079 3684	.000 976 5625
1025	1 050 625	1 076 890 625	32.015 6212	10.082 6484	.000 975 6098
1026	1 052 676	1 080 045 576	32.031 2348	10.085 9262	.000 974 6589
1027	1 054 729	1 083 206 683	32.046 8407	10.089 2019	.000 973 7098
1028	1 056 784	1 086 373 952	32.062 4391	10.092 4755	.000 972 7626
1029	1 058 841	1 089 517 389	32.078 0298	10.095 7469	.000 971 8173
1030	1 060 900	1 092 727 000	32.093 6131	10.099 0163	.000 970 8738
1031	1 062 961	1 095 912 791	32.109 1887	10.102 2835	.000 969 9321
1032	1 065 024	1 099 104 768	32.124 7568	10.105 5487	.000 968 9922
1033	1 067 089	1 102 302 937	32.140 3173	10.108 8117	.000 968 0542
1034	1 069 156	1 105 507 304	32.155 8704	10.112 0726	.000 967 1180
1035	1 071 225	1 108 717 875	32.171 4159	10.115 3314	.000 966 1836
1036	1 073 296	1 111 934 656	32.186 9539	10.118 5882	.000 965 2510
1037	1 075 369	1 115 157 653	32.202 4844	10.121 8428	.000 964 3202
1038	1 077 444	1 118 386 872	32.218 0074	10.125 0953	.000 963 3911
1039	1 079 521	1 121 622 319	32.233 5229	10.128 3457	.000 962 4639
1040	1 081 600	1 124 864 000	32.249 0310	10.131 5941	.000 961 5385

Number	Squares.	Cubes.	$\sqrt{}$ Roots.	$\sqrt[3]{}$ Roots.	Reciprocals.
1041	1 083 681	1 128 111 921	32.264 5316	10.134 8403	.000 960 6148
1042	1 085 764	1 131 366 088	32.280 0248	10.138 0845	.000 959 6929
1043	1 087 849	1 134 626 507	32.295 5105	10.141 3266	.000 958 7728
1044	1 089 936	1 137 893 184	32.310 9888	10.144 5667	.000 957 8544
1045	1 092 025	1 141 166 125	32.326 4598	10.147 8047	.000 956 9378
1046	1 094 116	1 144 445 336	32.341 9233	10.151 0406	.000 956 0229
1047	1 096 209	1 147 730 823	32.357 3794	10.154 2744	.000 955 1098
1048	1 098 304	1 151 022 592	32.372 8281	10.157 5062	.000 954 1985
1049	1 100 401	1 154 320 649	32.388 2695	10.160 7359	.000 953 2888
1050	1 102 500	1 157 625 000	32.403 7035	10.163 9636	.000 952 3810
1051	1 104 601	1 160 935 651	32.419 1301	10.167 1893	.000 951 4748
1052	1 106 704	1 164 252 608	32.434 5495	10.170 4129	.000 950 5703
1053	1 108 809	1 167 575 877	32.449 9615	10.173 6344	.000 949 6676
1054	1 110 916	1 170 905 464	32.465 3662	10.176 8539	.000 948 7666
1055	1 113 025	1 174 241 375	32.480 7635	10.180 0714	.000 947 8673
1056	1 115 136	1 177 583 616	32.496 1536	10.183 2868	.000 946 9697
1057	1 117 249	1 180 932 193	32.511 5364	10.186 5002	.000 946 0738
1058	1 119 364	1 184 287 112	32.526 9119	10.189 7116	.000 945 1796
1059	1 121 481	1 187 648 379	32.542 2802	10.192 9209	.000 944 2871
1060	1 123 600	1 191 016 000	32.557 6412	10.196 1283	.000 943 3962
1061	1 125 721	1 194 389 981	32.572 9949	10.199 3336	.000 942 5071
1062	1 127 844	1 197 770 328	32.588 3415	10.202 5369	.000 941 6196
1063	1 129 969	1 201 157 047	32.603 6807	10.205 7382	.000 940 7338
1064	1 132 096	1 204 550 144	32.619 0129	10.208 9375	.000 939 8496
1065	1 134 225	1 207 949 625	32.634 3377	10.212 1347	.000 938 9671
1066	1 136 356	1 211 355 496	32.649 6554	10.215 3300	.000 938 0863
1067	1 138 489	1 214 767 763	32.664 9659	10.218 5233	.000 937 2071
1068	1 140 624	1 218 186 432	32.680 2693	10.221 7146	.000 936 3296
1069	1 142 761	1 221 611 509	32.695 5654	10.224 9039	.000 935 4537
1070	1 144 900	1 225 043 000	32.710 8544	10.228 0912	.000 934 5794
1071	1 147 041	1 228 480 911	32.726 1363	10.231 2766	.000 933 7068
1072	1 149 184	1 231 925 248	32.741 4111	10.234 4599	.000 932 8358
1073	1 151 329	1 235 376 017	32.756 6787	10.237 6413	.000 931 9664
1074	1 153 476	1 238 833 224	32.771 9392	10.240 8207	.000 931 0987
1075	1 155 625	1 242 296 875	32.787 1926	10.243 9981	.000 930 2326
1076	1 157 776	1 245 766 976	32.802 4398	10.247 1735	.000 929 3680
1077	1 159 929	1 249 243 533	32.817 6782	10.250 3470	.000 928 5051
1078	1 162 084	1 252 726 552	32.832 9103	10.253 5186	.000 927 6438
1079	1 164 241	1 256 216 039	32.848 1354	10.256 6881	.000 926 7841
1080	1 166 400	1 259 712 000	32.863 3535	10.259 8557	.000 925 9259
1081	1 168 561	1 263 214 441	32.878 5644	10.263 0213	.000 925 0694
1082	1 170 724	1 266 723 368	32.893 7684	10.266 1850	.000 924 2144
1083	1 172 889	1 270 238 787	32.908 9653	10.269 3467	.000 923 3610
1084	1 175 056	1 273 760 704	32.924 1553	10.272 5065	.000 922 5092
1085	1 177 225	1 277 289 125	32.939 3382	10.275 6644	.000 921 6590
1086	1 179 396	1 280 824 056	32.954 5141	10.278 8203	.000 920 8103
1087	1 181 569	1 284 365 503	32.969 6830	10.281 9743	.000 919 9632
1088	1 183 744	1 287 913 472	32.984 8450	10.285 126[illegible]	.000 919 1176
1089	1 185 921	1 291 467 969	33.000 0000	10.288 2765	.000 918 2736
1090	*1 188 100*	1 295 029 000	33.015 1480	10.291 4247	.000 917 4310
1091	*1 190 281*	1 298 596 571	33.030 2891	10.294 5709	.000 916 5[illegible]
1092	*1 192 464*	1 302 170 688	33.045 4233	10.297 7153	.000 915 7[illegible]

Number	Squares.	Cubes.	$\sqrt{}$ Roots.	$\sqrt[3]{}$ Roots.	Reciprocals.
1093	1 194 649	1 305 751 357	33.060 5505	10.300 8577	.000 914 9131
1094	1 196 836	1 309 338 584	33.075 6708	10.303 9962	.000 914 0768
1095	1 199 025	1 312 932 375	33.090 7842	10.307 1368	.000 913 2420
1096	1 201 216	1 316 532 736	33.105 8907	10.310 2735	.000 912 4088
1097	1 203 409	1 320 139 673	33.120 9903	10.313 4063	.000 911 5770
1098	1 205 604	1 323 753 192	33.136 0830	10.316 5411	.000 910 7468
1099	1 207 801	1 327 373 299	33.151 1689	10.319 6721	.000 909 9181
1100	1 210 000	1 331 000 000	33.166 2479	10.322 8012	.000 909 0909
1101	1 212 201	1 334 633 301	33.181 3200	10.325 9284	.000 908 2652
1102	1 214 404	1 338 273 208	33.196 3853	10.329 0537	.000 907 4410
1103	1 216 609	1 341 919 727	33.211 4438	10.332 1770	.000 906 6183
1104	1 218 816	1 345 572 864	33.226 4955	10.335 2985	.000 905 7971
1105	1 221 025	1 349 232 625	33.241 5403	10.338 4181	.000 904 9774
1106	1 223 236	1 352 899 016	33.256 5783	10.341 5358	.000 904 1591
1107	1 225 449	1 356 572 043	33.271 6095	10.344 6517	.000 903 3424
1108	1 227 664	1 360 251 712	33.286 6339	10.347 7657	.000 902 5271
1109	1 229 881	1 363 938 029	33.301 6516	10.350 8778	.000 901 7133
1110	1 232 100	[illegible]	33.316 6625	10.353 9880	.000 900 9009
1111	1 234 321	[illegible]	33.331 6666	10.357 0964	.000 900 0900
1112	1 236 544	[illegible]	33.346 6640	10.360 2029	.000 899 2806
1113	1 238 769	[illegible]	33.361 6546	10.363 3076	.000 898 4726
1114	1 240 996	[illegible]	[illegible]	10.366 4103	.000 897 6661
1115	1 243 225	[illegible]	[illegible]	10.369 5113	.000 896 8610
1116	[illegible]	[illegible]	[illegible]	[illegible]	.000 896 0753
1117	1 247 689	[illegible]	[illegible]	10.375 7076	.000 895 2551
1118	[illegible]	[illegible]	[illegible]	[illegible]	.000 894 4544
1119	[illegible]	[illegible]	[illegible]	[illegible]	.000 893 6550
1120	[illegible]	[illegible]	[illegible]	[illegible]	.000 892 8571
1121	[illegible]	[illegible]	[illegible]	[illegible]	.000 891 0607
1122	[illegible]	[illegible]	[illegible]	[illegible]	.000 891 2656
1123	[illegible]	[illegible]	[illegible]	[illegible]	.000 890 4720
1124	[illegible]	[illegible]	[illegible]	[illegible]	.000 889 6797
1125	[illegible]	[illegible]	[illegible]	[illegible]	.000 888 8889
1126	[illegible]	[illegible]	[illegible]	[illegible]	.000 888 0995
1127	[illegible]	[illegible]	[illegible]	[illegible]	.000 887 3114
1128	[illegible]	[illegible]	[illegible]	[illegible]	.000 886 5248
1129	[illegible]	[illegible]	[illegible]	10.412 7310	.000 885 7396
1130	1 276 900	[illegible]	[illegible]	[illegible]	.000 884 9558
1131	[illegible]	[illegible]	[illegible]	[illegible]	.000 884 1733
1132	[illegible]	[illegible]	[illegible]	[illegible]	.000 883 3922
1133	[illegible]	[illegible]	[illegible]	[illegible]	.000 882 6125
1134	[illegible]	[illegible]	[illegible]	[illegible]	.000 881 8342
1135	[illegible]	[illegible]	[illegible]	[illegible]	.000 881 0573
1136	1 290 496	[illegible]	[illegible]	[illegible]	.000 880 2817
1137	[illegible]	[illegible]	[illegible]	[illegible]	.000 879 5075
1138	[illegible]	[illegible]	[illegible]	[illegible]	.000 878 7346
1139	[illegible]	[illegible]	[illegible]	[illegible]	.000 877 9631
1140	[illegible]	[illegible]	[illegible]	[illegible]	.000 877 1930
1141	1 301 881	[illegible]	[illegible]	[illegible]	[illegible]
1142	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1143	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1144	1 308 736	[illegible]	33.823 0691	[illegible]	[illegible]

Number	Squares.	Cubes.	√ Roots.	∛ Roots.	Reciprocals.
1145	1 311 025	1 501 123 625	33.837 8486	10.461 6896	.000 873 3624
1146	1 313 316	1 505 060 136	33.852 6218	10.464 7443	.000 872 6003
1147	1 315 609	1 509 003 523	33.867 3884	10.467 7773	.000 871 8396
1148	1 317 904	1 512 953 792	33.882 1487	10.470 8158	.000 871 0801
1149	1 320 201	1 516 910 949	33.896 9025	10.473 8579	.000 870 3220
1150	1 322 500	1 520 875 000	33.911 6499	10.476 8955	.000 869 5652
1151	1 324 801	1 524 845 951	33.926 3909	10.479 9314	.000 868 8097
1152	1 327 104	1 528 823 808	33.941 1255	10.482 9656	.000 868 0556
1153	1 329 409	1 532 808 577	33.955 8537	10.485 9980	.000 867 3027
1154	1 331 716	1 536 800 264	33.970 5755	10.489 0286	.000 866 5511
1155	1 334 025	1 540 798 875	33.985 2910	10.492 0575	.000 865 8009
1156	1 336 336	1 544 804 416	34.000 0000	10.495 0847	.000 865 0519
1157	1 338 649	1 548 816 893	34.014 7027	10.498 1101	.000 864 3042
1158	1 340 964	1 552 836 312	34.029 3990	10.501 1337	.000 863 5579
1159	1 343 281	1 556 862 679	34.044 0890	10.504 1556	.000 862 8128
1160	1 345 600	1 560 896 000	34.058 7727	10.507 1757	.000 862 0690
1161	1 347 921	1 564 936 281	34.073 4501	10.510 1942	.000 861 3264
1162	1 350 244	1 568 983 528	34.088 1211	10.513 2109	.000 860 5852
1163	1 352 569	1 573 037 747	34.102 7858	10.516 2259	.000 859 8452
1164	1 354 896	1 577 098 944	34.117 4442	10.519 2391	.000 859 1065
1165	1 357 225	1 581 167 125	34.132 0963	10.522 2506	.000 858 3691
1166	1 359 556	1 585 242 296	34.146 7422	10.525 2604	.000 857 6329
1167	1 361 889	1 589 324 463	34.161 3817	10.528 2685	.000 856 8980
1168	1 364 224	1 593 413 632	34.176 0150	10.531 2749	.000 856 1644
1169	1 366 561	1 597 509 809	34.190 6420	10.534 2795	.000 855 4320
1170	1 368 900	1 601 613 000	34.205 2627	10.537 2825	.000 854 7009
1171	1 371 241	1 605 723 211	34.219 8773	10.540 2837	.000 853 9710
1172	1 373 584	1 609 840 448	34.234 4855	10.543 2832	.000 853 2423
1173	1 375 929	1 613 964 717	34.249 0875	10.546 2810	.000 852 5149
1174	1 378 276	1 618 096 024	34.263 6834	10.549 2771	.000 851 7888
1175	1 380 625	1 622 234 375	34.278 2730	10.552 2715	.000 851 0638
1176	1 382 976	1 626 379 776	34.292 8564	10.555 2642	.000 850 3401
1177	1 385 329	1 630 532 233	34.307 4336	10.558 2552	.000 849 6177
1178	1 387 684	1 634 691 752	34.322 0046	10.561 2445	.000 848 8964
1179	1 390 041	1 638 858 339	34.336 5694	10.564 2322	.000 848 1764
1180	1 392 400	1 643 032 000	34.351 1281	10.567 2181	.000 847 4576
1181	1 394 761	1 647 212 741	34.365 6805	10.570 2024	.000 846 7401
1182	1 397 124	1 651 400 568	34.380 2268	10.573 1849	.000 846 0237
1183	1 399 489	1 655 595 487	34.394 7670	10.576 1658	.000 845 3085
1184	1 401 856	1 659 797 504	34.409 3011	10.579 1449	.000 844 5946
1185	1 404 225	1 664 006 625	34.423 8289	10.582 1225	.000 843 8819
1186	1 406 596	1 668 222 856	34.438 3507	10.585 0983	.000 843 1703
1187	1 408 969	1 672 446 203	34.452 8663	10.588 0725	.000 842 4600
1188	1 411 344	1 676 676 672	34.467 3759	10.591 0450	.000 841 7508
1189	1 413 721	1 680 914 269	34.481 8793	10.594 0158	.000 841 0429
1190	1 416 100	1 685 159 000	34.496 3766	10.596 9850	.000 840 3361
1191	1 418 481	1 689 410 871	34.510 8678	10.599 9525	.000 839 6306
1192	1 420 864	1 693 669 888	34.525 3530	10.602 9184	.000 838 9262
1193	1 423 249	1 697 936 057	34.539 8321	10.605 8826	.000 838 2230
1194	1 425 636	1 702 209 384	34.554 3051	10.608 8451	.000 837 5209
1195	1 428 025	1 706 489 875	34.568 7720	10.611 8060	.000 836 8201
1196	1 430 416	1 710 777 536	34.583 2329	10.614 7652	.000 836 1

Number	Squares.	Cubes.	$\sqrt{\ }$ Roots.	$\sqrt[3]{\ }$ Roots.	Reciprocals.
1197	1 432 809	1 715 072 373	34.597 6879	10.617 7228	.000 835 4219
1198	1 435 204	1 719 374 392	34.612 1366	10.620 6788	.000 834 7245
1199	1 437 601	1 723 683 599	34.626 5794	10.623 6331	.000 834 0284
1200	1 440 000	1 728 000 000	34.641 0162	10.626 5857	.000 833 3333
1201	1 442 401	1 732 323 601	34.655 4469	10.629 5367	.000 832 6395
1202	1 444 804	1 736 654 408	34.669 8716	10.632 4860	.000 831 9468
1203	1 447 209	1 740 992 427	34.684 2904	10.635 4338	.000 831 2552
1204	1 449 616	1 745 337 664	34.698 7031	10.638 3799	.000 830 5648
1205	1 452 025	1 749 690 125	34.713 1099	10.641 3244	.000 829 8755
1206	1 454 436	1 754 049 816	34.727 5107	10.644 2672	.000 829 1874
1207	1 456 849	1 758 416 743	34.741 9055	10.647 2085	.000 828 5004
1208	1 459 264	1 762 790 912	34.756 2944	10.650 1480	.000 827 8146
1209	1 461 681	1 767 172 329	34.770 6773	10.653 0860	.000 827 1299
1210	1 464 100	1 771 561 000	34.785 0543	10.656 0223	.000 826 4463
1211	1 466 521	1 775 956 931	34.799 4253	10.658 9570	.000 825 7638
1212	1 468 944	1 780 360 128	34.813 7904	10.661 8902	.000 825 0825
1213	1 471 369	1 784 770 597	34.828 1495	10.664 8217	.000 824 4023
1214	1 473 796	1 789 188 344	34.842 5028	10.667 7516	.000 823 7232
1215	1 476 225	1 793 613 375	34.856 8501	10.670 6799	.000 823 0453
1216	1 478 656	1 798 045 696	34.871 1915	10.673 6066	.000 822 3684
1217	1 481 089	1 802 485 313	34.885 5271	10.676 5317	.000 821 6927
1218	1 483 524	1 806 932 232	34.899 8567	10.679 4552	.000 821 0181
1219	1 485 961	1 811 386 459	34.914 1805	10.682 3771	.000 820 3445
1220	1 488 400	1 815 848 000	34.928 4984	10.685 2973	.000 819 6721
1221	1 490 841	1 820 316 861	34.942 8104	10.688 2160	.000 819 0008
1222	1 493 284	1 824 793 048	34.957 1166	10.691 1331	.000 818 3306
1223	1 495 729	1 829 276 567	34.971 4169	10.694 0486	.000 817 6615
1224	1 498 176	1 833 767 424	34.985 7114	10.696 9625	.000 816 9935
1225	1 500 625	1 838 265 625	35.000 0000	10.699 8748	.000 816 3265
1226	1 503 076	1 842 771 176	35.014 2828	10.702 7855	.000 815 6607
1227	1 505 529	1 847 284 083	35.028 5598	10.705 6947	.000 814 9959
1228	1 507 984	1 851 804 352	35.042 8309	10.708 6023	.000 814 3322
1229	1 510 441	1 856 331 989	35.057 0963	10.711 5083	.000 813 6696
1230	1 512 900	1 860 867 000	35.071 3558	10.714 4127	.000 813 0081
1231	1 515 361	1 865 409 391	35.085 6096	10.717 3155	.000 812 3477
1232	1 517 824	1 869 959 168	35.099 8575	10.720 2168	.000 811 6883
1233	1 520 289	1 874 516 337	35.114 0997	10.723 1165	.000 811 0300
1234	1 522 756	1 879 080 904	35.128 3361	10.726 0146	.000 810 3728
1235	1 525 225	1 883 652 875	35.142 5668	10.728 9112	.000 809 7166
1236	1 527 696	1 888 232 256	35.156 7917	10.731 8062	.000 809 0615
1237	1 530 169	1 892 819 053	35.171 0108	10.734 6997	.000 808 4074
1238	1 532 644	1 897 413 272	35.185 2242	10.737 5916	.000 807 7544
1239	1 535 121	1 902 014 919	35.199 4318	10.740 4819	.000 807 1025
1240	1 537 600	1 906 624 000	35.213 6337	10.743 3707	.000 806 4516
1241	1 540 081	1 911 240 521	35.227 8299	10.746 2579	.000 805 8018
1242	1 542 564	1 915 864 488	35.242 0204	10.749 1436	.000 805 1530
1243	1 545 049	1 920 495 907	35.256 2051	10.752 0277	.000 804 5052
1244	1 547 536	1 925 134 784	35.270 3842	10.754 9103	.000 803 8585
1245	1 550 025	1 929 781 125	35.284 5575	10.757 7913	.000 803 2129
1246	1 552 516	1 934 434 936	35.298 7252	10.760 6708	.000 802 5682
1247	1 555 009	1 939 096 223	35.312 8872	10.763 5488	.000 801 9246
1248	1 557 504	1 943 764 992	35.327 0435	10.766 4252	.000 801 2821

Number	Squares.	Cubes.	√ Roots.	∛ Roots.	Reciprocals.
1249	1 560 001	1 948 441 249	35.341 1941	10.769 3001	.000 800 6405
1250	1 562 500	1 953 125 000	35.355 3391	10.772 1735	.000 800 0000
1251	1 565 001	1 957 816 251	35.369 4784	10.775 0453	.000 799 3605
1252	1 567 504	1 962 515 008	35.383 6120	10.777 9156	.000 798 7220
1253	1 570 009	1 967 221 277	35.397 7400	10.780 7843	.000 798 0846
1254	1 572 516	1 971 935 064	35.411 8624	10.783 6516	.000 797 4482
1255	1 575 025	1 976 656 375	35.425 9792	10.786 5173	.000 796 8127
1256	1 577 536	1 981 385 216	35.440 0903	10.789 3815	.000 796 1783
1257	1 580 049	1 986 121 593	35.454 1958	10.792 2441	.000 795 5449
1258	1 582 564	1 990 865 512	35.468 2957	10.795 1053	.000 794 9126
1259	1 585 081	1 995 616 979	35.482 3900	10.797 9649	.000 794 2812
1260	1 587 600	2 000 376 000	35.496 4787	10.800 8230	.000 793 6508
1261	1 590 121	2 005 142 581	35.510 5618	10.803 6797	.000 793 0214
1262	1 592 644	2 009 916 728	35.524 6393	10.806 5348	.000 792 3930
1263	1 595 169	2 014 698 447	35.538 7113	10.809 3884	.000 791 7656
1264	1 597 696	2 019 487 744	35.552 7777	10.812 2404	.000 791 1392
1265	1 600 225	2 024 284 625	35.566 8385	10.815 0909	.000 790 5138
1266	1 602 756	2 029 089 096	35.580 8937	10.817 9400	.000 789 8894
1267	1 605 289	2 033 901 163	35.594 9434	10.820 7876	.000 789 2660
1268	1 607 824	2 038 720 832	35.608 9876	10.823 6336	.000 788 6435
1269	1 610 361	2 043 548 109	35.623 0262	10.826 4782	.000 788 0221
1270	1 612 900	2 048 383 000	35.637 0593	10.829 3213	.000 787 4016
1271	1 615 441	2 053 225 511	35.651 0869	10.832 1629	.000 786 7821
1272	1 617 984	2 058 075 648	35.665 1090	10.835 0030	.000 786 1635
1273	1 620 529	2 062 933 417	35.679 1255	10.837 8416	.000 785 5460
1274	1 623 076	2 067 798 824	35.693 1366	10.840 6788	.000 784 9294
1275	1 625 625	2 072 671 875	35.707 1421	10.843 5144	.000 784 3137
1276	1 628 176	2 077 552 576	35.721 1422	10.846 3485	.000 783 6991
1277	1 630 729	2 082 440 933	35.735 1367	10.849 1812	.000 783 0854
1278	1 633 284	2 087 336 952	35.749 1258	10.852 0125	.000 782 4726
1279	1 635 841	2 092 240 639	35.763 1095	10.854 8422	.000 781 8608
1280	1 638 400	2 097 152 000	35.777 0876	10.857 6704	.000 781 2500
1281	1 640 961	2 102 071 041	35.791 0603	10.860 4972	.000 780 6401
1282	1 643 524	2 106 997 768	35.805 0276	10.863 3225	.000 780 0312
1283	1 646 089	2 111 932 187	35.818 9894	10.866 1454	.000 779 4232
1284	1 648 656	2 116 874 304	35.832 9457	10.868 9687	.000 778 8162
1285	1 651 225	2 121 824 125	35.846 8966	10.871 7897	.000 778 2101
1286	1 653 796	2 126 781 656	35.860 8421	10.874 6091	.000 777 6050
1287	1 656 369	2 131 746 903	35.874 7822	10.877 4271	.000 777 0008
1288	1 658 944	2 136 719 872	35.888 7169	10.880 2436	.000 776 3975
1289	1 661 521	2 141 700 569	35.902 6461	10.883 0587	.000 775 7952
1290	1 664 100	2 146 689 000	35.916 5699	10.885 8723	.000 775 1938
1291	1 666 681	2 151 685 171	35.930 4884	10.888 6845	.000 774 5933
1292	1 669 264	2 156 689 088	35.944 4015	10.891 4952	.000 773 9938
1293	1 671 849	2 161 700 757	35.958 3092	10.894 3044	.000 773 3952
1294	1 674 436	2 166 720 184	35.972 2115	10.897 1123	.000 772 7975
1295	1 677 025	2 171 747 375	35.986 1084	10.899 9186	.000 772 2008
1296	1 679 616	2 176 782 336	36.000 0000	10.902 7235	.000 771 6049
1297	1 682 209	2 181 825 073	36.013 8862	10.905 5269	.000 771 0100
1298	1 684 804	2 186 875 592	36.027 7671	10.908 3290	.000 770 4160
1299	1 687 401	2 191 933 899	36.041 6426	10.911 1296	.000 769 8229
1300	1 690 000	2 197 000 000	36.055 5128	10.913 9287	.000 769 2308

Number.	Squares.	Cubes.	$\sqrt{}$ Roots.	$\sqrt[3]{}$ Roots.	Reciprocals.
1301	1 692 601	2 202 073 901	36.069 3776	10.916 7265	.000 768 6395
1302	1 695 204	2 207 155 608	36.083 2371	10.919 5228	.000 768 0492
1303	1 697 809	2 212 245 127	36.097 0913	10.922 3177	.000 767 4579
1304	1 700 416	2 217 342 464	36.110 9402	10.925 1111	.000 766 8712
1305	1 703 025	2 222 447 625	36.124 7837	10.927 9031	.000 766 2835
1306	1 705 636	2 227 560 616	36.138 6220	10.930 6937	.000 765 6968
1307	1 708 249	2 232 681 443	36.152 4550	10.933 4829	.000 765 1109
1308	1 710 864	2 237 810 112	36.166 2826	10.936 2706	.000 764 5260
1309	1 713 481	2 242 946 629	36.180 1050	10.939 0569	.000 763 9419
1310	1 716 100	2 248 091 000	36.193 9221	10.941 8418	.000 763 3588
1311	1 718 721	2 253 243 231	36.207 7340	10.944 6253	.000 762 7765
1312	1 721 344	2 258 403 328	36.221 5406	10.947 5074	.000 762 1951
1313	1 723 969	2 263 571 297	36.235 3419	10.950 1880	.000 761 6446
1314	1 726 596	2 268 747 144	36.249 1379	10.952 9673	.000 761 0350
1315	1 729 225	2 273 930 875	36.262 6287	10.955 7451	.000 760 4563
1316	1 731 856	2 279 122 496	36.276 7143	10.958 5215	.000 759 8784
1317	1 734 489	2 284 322 013	36.290 4246	10.961 2965	.000 759 3014
1318	1 737 124	2 289 529 432	36.304 2697	10.964 0701	.000 758 7253
1319	1 739 761	2 294 744 759	36.318 0396	10.966 8423	.000 758 1501
1320	1 742 400	2 299 968 000	36.331 8042	10.969 6131	.000 757 5758
1321	1 745 041	2 305 199 161	36.345 5637	10.972 3825	.000 757 0023
1322	1 747 684	2 310 438 248	36.359 3179	10.975 1505	.000 756 4297
1323	1 750 329	2 315 685 267	36.373 0670	10.977 9171	.000 755 8579
1324	1 752 976	2 320 940 224	36.386 8108	10.980 6823	.000 755 2870
1325	1 755 625	2 326 203 125	36.400 5494	10.983 4462	.000 754 7170
1326	1 758 276	2 331 473 976	36.414 2829	10.986 2066	.000 754 1478
1327	1 760 929	2 336 752 783	36.428 0112	10.988 9696	.000 753 5795
1328	1 763 584	2 342 039 552	36.441 7343	10.991 7293	.000 753 0120
1329	1 766 241	2 347 334 289	36.455 4523	10.994 4876	.000 752 4454
1330	1 768 900	2 352 637 000	36.469 1650	10.997 2445	.000 751 8797
1331	1 771 561	2 357 947 691	36.482 8727	11.000 0000	.000 751 3148
1332	1 774 224	2 363 266 368	36.496 5752	11.002 7541	.000 750 7508
1333	1 776 889	2 368 593 037	36.510 2725	11.005 5069	.000 750 1875
1334	1 779 556	2 373 927 704	36.523 9647	11.008 2583	.000 749 6252
1335	1 782 225	2 379 270 375	36.537 6518	11.011 0082	.000 749 0637
1336	1 784 896	2 384 621 056	36.551 3338	11.013 7569	.000 748 5030
1337	1 787 569	2 389 979 753	36.565 0106	11.016 5041	.000 747 9432
1338	1 790 244	2 395 346 472	36.578 6823	11.019 2500	.000 747 3842
1339	1 792 921	2 400 721 219	36.592 3489	11.021 9945	.000 746 8260
1340	1 795 600	2 406 104 000	36.606 0104	11.024 7377	.000 746 2687
1341	1 798 281	2 411 494 821	36.619 6668	11.027 4795	.000 745 7122
1342	1 800 964	2 416 893 688	36.633 3181	11.030 2199	.000 745 1565
1343	1 803 649	2 422 300 607	36.646 9144	11.032 9590	.000 744 6016
1344	1 806 336	2 427 715 584	36.660 6056	11.035 6967	.000 744 0476
1345	1 809 025	2 433 138 625	36.674 2416	11.038 4330	.000 743 4944
1346	1 811 716	2 438 569 736	36.687 8726	11.041 1680	.000 742 9421
1347	1 814 409	2 444 008 923	36.701 4986	11.043 9017	.000 742 3905
1348	1 817 104	2 449 456 192	36.715 1195	11.046 6339	.000 741 8398
1349	1 819 801	2 454 911 549	36.728 7353	11.049 3649	.000 741 2898
1350	1 822 500	2 460 375 000	36.742 3461	11.052 0945	.000 740 7407
1351	1 825 201	2 465 846 551	36.755 9519	11.054 8227	.000 740 1924
1352	1 827 904	2 471 326 208	36.769 5526	11.057 5497	.000 739 6450

Number.	Squares.	Cubes.	√ Roots.	∛ Roots.	Reciprocals.
1353	1 830 609	2 476 813 977	36.783 1483	11.060 2752	.000 739 0983
1354	1 833 316	2 482 309 864	36.796 7390	11.062 9994	.000 738 5524
1355	1 836 025	2 487 813 875	36.810 3246	11.065 7222	.000 738 0074
1356	1 838 736	2 493 326 016	36.823 9053	11.068 4437	.000 737 4631
1357	1 841 449	2 498 846 293	36.837 4809	11.071 1639	.000 736 9197
1358	1 844 164	2 504 374 712	36.851 0515	11.073 8828	.000 736 3770
1359	1 846 881	2 509 911 279	36.864 6172	11.076 6003	.000 735 8352
1360	1 849 600	2 515 456 000	36.878 1778	11.079 3165	.000 735 2941
1361	1 852 321	2 521 008 881	36.891 7335	11.082 0314	.000 734 7539
1362	1 855 044	2 526 569 928	36.905 2842	11.084 7449	.000 734 2144
1363	1 857 769	2 532 139 147	36.918 8299	11.087 4571	.000 733 6757
1364	1 860 496	2 537 716 544	36.932 3706	11.090 1679	.000 733 1378
1365	1 863 225	2 543 302 125	36.945 9064	11.092 8775	.000 732 6007
1366	1 865 956	2 548 895 896	36.959 4372	11.095 5857	.000 732 0644
1367	1 868 689	2 554 497 863	36.972 9631	11.098 2926	.000 731 5289
1368	1 871 424	2 560 108 032	36.986 4840	11.100 9982	.000 730 9942
1369	1 874 161	2 565 726 409	37.000 0000	11.103 7025	.000 730 4602
1370	1 876 900	2 571 353 000	37.013 5110	11.106 4054	.000 729 9270
1371	1 879 641	2 576 987 811	37.027 0172	11.109 1070	.000 729 3946
1372	1 882 384	2 582 630 848	37.040 5184	11.111 8073	.000 728 8630
1373	1 885 129	2 588 282 117	37.054 0146	11.114 5064	.000 728 3321
1374	1 887 876	2 593 941 624	37.067 5060	11.117 2041	.000 727 8020
1375	1 890 625	2 599 609 375	37.080 9924	11.119 9004	.000 727 2727
1376	1 893 376	2 605 285 376	37.094 4740	11.122 5955	.000 726 7442
1377	1 896 129	2 610 969 633	37.107 9506	11.125 2893	.000 726 2164
1378	1 898 884	2 616 662 152	37.121 4224	11.127 9817	.000 725 6894
1379	1 901 641	2 622 362 939	37.134 8893	11.130 6729	.000 725 1632
1380	1 904 400	2 628 072 000	37.148 3512	11.133 3628	.000 724 6377
1381	1 907 161	2 633 789 341	37.161 8084	11.136 0514	.000 724 1130
1382	1 909 924	2 639 514 968	37.175 2606	11.138 7386	.000 723 5890
1383	1 912 689	2 645 248 887	37.188 7079	11.141 4246	.000 723 0658
1384	1 915 456	2 650 991 104	37.202 1505	11.144 1093	.000 722 5434
1385	1 918 225	2 656 741 625	37.215 5881	11.146 7926	.000 722 0217
1386	1 920 996	2 662 500 456	37.229 0209	11.149 4747	.000 721 5007
1387	1 923 769	2 668 267 603	37.242 4489	11.152 1555	.000 720 9805
1388	1 926 544	2 674 043 072	37.255 8720	11.154 8350	.000 720 4611
1389	1 929 321	2 679 826 869	37.269 2903	11.157 5133	.000 719 9424
1390	1 932 100	2 685 619 000	37.282 7037	11.160 1903	.000 719 4245
1391	1 934 881	2 691 419 471	37.296 1124	11.162 8659	.000 718 9073
1392	1 937 664	2 697 228 288	37.309 5162	11.165 5403	.000 718 3908
1393	1 940 449	2 703 045 457	37.322 9152	11.168 2134	.000 717 8751
1394	1 943 236	2 708 870 984	37.336 3094	11.170 8852	.000 717 3601
1395	1 946 025	2 714 704 875	37.349 6988	11.173 5558	.000 716 8459
1396	1 948 816	2 720 547 136	37.363 0834	11.176 2250	.000 716 3324
1397	1 951 609	2 726 397 773	37.376 4632	11.178 8930	.000 715 8196
1398	1 954 404	2 732 256 792	37.389 8382	11.181 5598	.000 715 3076
1399	1 957 201	2 738 124 199	37.403 2084	11.184 2252	.000 714 7963
1400	1 960 000	2 744 000 000	37.416 5738	11.186 8894	.000 714 2857
1401	1 962 801	2 749 884 201	37.429 9345	11.189 5523	.000 713 7759
1402	*1 965 604*	2 755 776 808	37.443 2904	11.192 2139	.000 713 2668
1403	*1 968 409*	2 761 677 827	37.456 6416	11.194 8743	.000 712 758
1404	*1 971 216*	2 767 587 264	37.469 9880	11.197 5824	.000 712 2[illegible]

Number.	Squares.	Cubes.	$\sqrt{}$ Roots.	$\sqrt[3]{}$ Roots.	Reciprocals.
1405	1 974 025	2 773 505 125	37.483 3296	11.200 1913	.000 711 7438
1406	1 976 836	2 779 431 416	37.496 6665	11.202 8479	.000 711 2376
1407	1 979 649	2 785 366 143	37.509 9987	11.205 5032	.000 710 7321
1408	1 982 464	2 791 309 312	37.523 3261	11.208 1573	.000 710 2273
1409	1 985 281	2 797 260 929	37.536 6487	11.210 8101	.000 709 7232
1410	1 988 100	2 803 221 000	37.549 9667	11.213 4617	.000 709 2199
1411	1 990 921	2 809 189 531	37.563 2799	11.216 1120	.000 708 7172
1412	1 993 744	2 815 166 528	37.576 5885	11.218 7611	.000 708 2153
1413	1 996 569	2 821 151 997	37.589 8922	11.221 4089	.000 707 7141
1414	1 999 396	2 827 145 944	37.603 1913	11.224 0054	.000 707 2136
1415	2 002 225	2 833 148 375	37.616 4857	11.226 7007	.000 706 7138
1416	2 005 056	2 839 159 296	37.629 7754	11.229 3448	.000 706 2147
1417	2 007 889	2 845 178 713	37.643 0604	11.231 9876	.000 705 7163
1418	2 010 724	2 851 206 632	37.656 3407	11.234 6292	.000 705 2186
1419	2 013 561	2 857 243 059	37.669 6164	11.237 2696	.000 704 7216
1420	2 016 400	2 863 288 000	37.682 8874	11.239 9087	.000 704 2254
1421	2 019 241	2 869 341 461	37.696 1536	11.242 5465	.000 703 7298
1422	2 022 084	2 875 403 448	37.709 4153	11.245 1831	.000 703 2349
1423	2 024 929	2 881 473 967	37.722 6722	11.247 8185	.000 702 7407
1424	2 027 776	2 887 553 024	37.735 9245	11.250 4527	.000 702 2472
1425	2 030 625	2 893 640 625	37.749 1722	11.253 0856	.000 701 7544
1426	2 033 476	2 899 736 776	37.762 4152	11.255 7173	.000 701 2623
1427	2 036 329	2 905 841 483	37.775 6535	11.258 3478	.000 700 7708
1428	2 039 184	2 911 954 752	37.788 8873	11.260 9770	.000 700 2801
1429	2 042 041	2 918 076 589	37.802 1163	11.263 6050	.000 699 7901
1430	2 044 900	2 924 207 000	37.815 3408	11.266 2318	.000 699 3007
1431	2 047 761	2 930 345 991	37.828 5606	11.268 8573	.000 698 8120
1432	2 050 624	2 936 493 568	37.841 7759	11.271 4816	.000 698 3240
1433	2 053 489	2 942 649 737	37.854 9864	11.274 1047	.000 697 8367
1434	2 056 356	2 948 814 504	37.868 1924	11.276 7266	.000 697 3501
1435	2 059 225	2 954 987 875	37.881 3938	11.279 3472	.000 696 8641
1436	2 062 096	2 961 169 856	37.894 5906	11.281 9666	.000 696 3788
1437	2 064 969	2 967 360 453	37.907 7828	11.284 5849	.000 695 8942
1438	2 067 844	2 973 559 672	37.920 9704	11.287 2019	.000 695 4103
1439	2 070 721	2 979 767 519	37.934 1535	11.289 8177	.000 694 9270
1440	2 073 600	2 985 984 000	37.947 3319	11.292 4323	.000 694 4444
1441	2 076 481	2 992 209 121	37.960 5058	11.295 0457	.000 693 9625
1442	2 079 364	2 998 442 888	37.973 6751	11.297 6579	.000 693 4813
1443	2 082 249	3 004 685 307	37.986 8398	11.300 2688	.000 693 0007
1444	2 085 136	3 010 936 384	38.000 0000	11.302 8786	.000 692 5208
1445	2 088 025	3 017 196 125	38.013 1556	11.305 4871	.000 692 0415
1446	2 090 916	3 023 464 536	38.026 3067	11.308 0945	.000 691 5629
1447	2 093 809	3 029 741 623	38.039 4532	11.310 7006	.000 691 0850
1448	2 096 704	3 036 027 392	38.052 5952	11.313 3056	.000 690 6078
1449	2 099 601	3 042 321 849	38.065 7326	11.315 9094	.000 690 1312
1450	2 102 500	3 048 625 000	38.078 8655	11.318 5119	.000 689 6552
1451	2 105 401	3 054 936 851	38.091 9939	11.321 1132	.000 689 1799
1452	2 108 304	3 061 257 408	38.105 1178	11.323 7134	.000 688 7052
1453	2 111 209	3 067 586 777	38.118 2371	11.326 3124	.000 688 2312
1454	2 114 116	3 073 924 664	38.131 3519	11.328 9102	.000 687 7579
1455	2 117 025	3 080 271 375	38.144 4622	11.331 5067	.000 687 2852
1456	2 119 936	3 086 626 816	38.157 5681	11.334 1022	.000 686 8132

Number.	Squares.	Cubes.	√ Roots.	∛ Roots.	Reciprocals.
1457	2 122 849	3 092 990 993	38.170 6693	11.336 6964	.000 686 3412
1458	2 125 764	3 099 363 912	38.183 7662	11.339 2894	.000 685 8711
1459	2 128 681	3 105 745 579	38.196 8585	11.341 8813	.000 685 4010
1460	2 131 600	3 112 136 000	38.209 9463	11.344 4719	.000 684 9315
1461	2 134 521	3 118 535 181	38.223 0297	11.347 0614	.000 684 4627
1462	2 137 444	3 124 943 128	38.236 1085	11.349 6497	.000 683 9945
1463	2 140 369	3 131 359 847	38.249 1829	11.352 2368	.000 683 5270
1464	2 143 296	3 137 785 344	38.262 2529	11.354 8227	.000 683 0601
1465	2 146 225	3 144 219 625	38.275 3184	11.357 4075	.000 682 5939
1466	2 149 156	3 150 662 696	38.288 3794	11.359 9911	.000 682 1282
1467	2 152 089	3 157 114 563	38.301 4360	11.362 5735	.000 681 6633
1468	2 155 024	3 163 575 232	38.314 4881	11.365 1547	.000 681 1989
1469	2 157 961	3 170 044 709	38.327 5358	11.367 7347	.000 680 7352
1470	2 160 900	3 176 523 000	38.340 5790	11.370 3136	.000 680 2721
1471	2 163 841	3 183 010 111	38.353 6178	11.372 8914	.000 679 8097
1472	2 166 784	3 189 506 048	38.366 6522	11.375 4679	.000 679 3478
1473	2 169 729	3 196 010 817	38.379 6821	11.378 0433	.000 678 8866
1474	2 172 676	3 202 524 424	38.392 7076	11.380 6175	.000 678 4261
1475	2 175 625	3 209 046 875	38.405 7287	11.383 1906	.000 677 9661
1476	2 178 576	3 215 578 176	38.418 7454	11.385 7625	.000 677 5068
1477	2 181 529	3 222 118 333	38.431 7577	11.388 3332	.000 677 0481
1478	2 184 484	3 228 667 352	38.444 7656	11.390 9028	.000 676 5900
1479	2 187 441	3 235 225 239	38.457 7691	11.393 4712	.000 676 1325
1480	2 190 400	3 241 792 000	38.470 7681	11.396 0384	.000 675 6757
1481	2 193 361	3 248 367 641	38.483 7627	11.398 6045	.000 675 2194
1482	2 196 324	3 254 952 168	38.496 7530	11.401 1695	.000 674 7638
1483	2 199 289	3 261 545 587	38.509 7390	11.403 7332	.000 674 3088
1484	2 202 256	3 268 147 904	38.522 7206	11.406 2959	.000 673 8544
1485	2 205 225	3 274 759 125	38.535 6977	11.408 8574	.000 673 4007
1486	2 208 196	3 281 379 256	38.548 6705	11.411 4177	.000 672 9474
1487	2 211 169	3 288 008 303	38.561 6389	11.413 9769	.000 672 4950
1488	2 214 144	3 294 646 272	38.574 6030	11.416 5349	.000 672 0430
1489	2 217 121	3 301 293 169	38.587 5627	11.419 0918	.000 671 5917
1490	2 220 100	3 307 949 000	38.600 5181	11.420 6476	.000 671 1409
1491	2 223 081	3 314 613 771	38.613 4691	11.424 2022	.000 670 6908
1492	2 226 064	3 321 287 488	38.626 4158	11.426 7556	.000 670 2413
1493	2 229 049	3 327 970 157	38.639 3582	11.429 3079	.000 669 7924
1494	2 232 036	3 334 661 784	38.652 2962	11.431 8591	.000 669 3440
1495	2 235 025	3 341 362 375	38.665 2299	11.434 4092	.000 668 8963
1496	2 238 016	3 348 071 936	38.678 1593	11.436 9581	.000 668 4492
1497	2 241 009	3 354 790 473	38.691 0843	11.439 5059	.000 668 0027
1498	2 244 004	3 361 517 992	38.704 0050	11.442 0525	.000 667 5567
1499	2 247 001	3 368 254 499	38.716 9214	11.444 5980	.000 667 1114
1500	2 250 000	3 375 000 000	38.729 8335	11.447 1424	.000 666 6667
1501	2 253 001	3 381 754 501	38.742 7412	11.449 6857	.000 666 2225
1502	2 256 004	3 388 518 008	38.755 6447	11.452 2278	.000 665 7790
1503	2 259 009	3 395 290 527	38.768 5439	11.454 7688	.000 655 3360
1504	2 262 016	3 402 072 064	38.781 4389	11.457 3087	.000 664 8936
1505	2 265 025	3 408 862 625	38.794 3294	11.459 8476	.000 664 4518
1506	2 268 036	3 415 662 216	38.807 2158	11.462 3850	.000 664 0106
1507	2 271 049	3 422 470 843	38.820 0978	11.464 9215	.000 663 5700
1508	2 274 064	3 429 288 512	38.832 9757	11.467 4568	.000 663 1300

Number.	Squares.	Cubes.	$\sqrt{\ }$ Roots.	$\sqrt[3]{\ }$ Roots.	Reciprocals.
1509	2 277 081	3 436 115 229	38.845 8491	11.469 9911	.000 662 6905
1510	2 280 100	3 442 951 000	38.858 7184	11.472 5242	.000 662 2517
1511	2 283 121	3 449 795 831	38.871 5834	11.475 0562	.000 661 8134
1512	2 286 144	3 456 649 728	38.884 4442	11.477 5871	.000 661 3757
1513	2 289 169	3 463 512 697	38.897 3006	11.480 1169	.000 660 9385
1514	2 292 196	3 470 384 744	38.910 1529	11.482 6455	.000 660 5020
1515	2 295 225	3 477 265 875	38.923 0009	11.485 1731	.000 660 0660
1516	2 298 256	3 484 156 096	38.935 8447	11.487 6995	.000 659 6306
1517	2 301 289	3 491 055 413	38.948 6841	11.490 2249	.000 659 1958
1518	2 304 324	3 597 963 832	38.961 5194	11.492 7491	.000 658 7615
1519	2 307 361	3 504 881 359	38.974 3505	11.495 2722	.000 658 3278
1520	2 310 400	3 511 808 000	38.987 1774	11.497 7942	.000 657 8947
1521	2 313 441	3 518 743 761	39.000 0000	11.500 3151	.000 657 4622
1522	2 316 484	3 525 688 648	39.012 8184	11.502 8348	.000 657 0302
1523	2 319 529	3 532 642 667	39.025 6326	11.505 3535	.000 656 5988
1524	2 322 576	3 539 605 824	39.038 4426	11.507 8711	.000 656 1680
1525	2 325 625	3 546 578 125	39.051 2483	11.510 3876	.000 655 7377
1526	2 328 676	3 553 559 576	39.064 0499	11.512 9030	.000 655 3080
1527	2 331 729	3 560 558 183	39.076 8473	11.515 4173	.000 654 8788
1528	2 334 784	3 567 549 552	39.089 6406	11.517 9305	.000 654 4503
1529	2 337 841	3 574 558 889	39.102 4296	11.520 4425	.000 654 0222
1530	2 340 900	3 581 577 000	39.115 2144	11.522 9535	.000 653 5948
1531	2 343 961	3 588 604 291	39.127 9951	11.525 4634	.000 653 1679
1532	2 347 024	3 595 640 768	39.140 7716	11.527 9722	.000 652 7415
1533	2 350 089	3 602 686 437	39.153 5439	11.530 4799	.000 652 3157
1534	2 353 156	3 609 741 304	39.166 3120	11.532 9865	.000 651 8905
1535	2 356 225	3 616 805 375	39.179 0760	11.535 4920	.000 651 4658
1536	2 359 296	3 623 878 656	39.191 8359	11.537 9965	.000 651 0417
1537	2 362 369	3 630 961 153	39.204 5915	11.540 4998	.000 650 6181
1538	2 365 444	3 638 052 872	39.217 3431	11.543 0021	.000 650 1951
1539	2 368 521	3 645 153 819	39.230 0905	11.545 5033	.000 649 7726
1540	2 371 600	3 652 264 000	39.242 8337	11.548 0034	.000 649 3506
1541	2 374 681	3 657 983 421	39.255 5728	11.550 5025	.000 648 9293
1542	2 377 764	3 666 512 088	39.268 3078	11.553 0004	.000 648 5084
1543	2 380 849	3 673 650 007	39.281 0387	11.555 4972	.000 648 0881
1544	2 383 936	3 680 797 184	39.293 7654	11.557 9931	.000 647 6684
1545	2 387 025	3 687 953 625	39.306 4880	11.560 4878	.000 647 2492
1546	2 390 116	3 695 119 336	39.319 2065	11.562 9815	.000 646 8305
1547	2 393 209	3 702 294 323	39.331 9208	11.565 4740	.000 646 4124
1548	2 396 304	3 709 478 592	39.344 6311	11.567 9655	.000 645 9948
1549	2 399 401	3 716 672 149	39.357 3373	11.570 4559	.000 645 5778
1550	2 402 500	3 723 875 000	39.370 0394	11.572 9453	.000 645 1613
1551	2 405 601	3 731 087 151	39.382 7373	11.575 4336	.000 644 7453
1552	2 408 704	3 738 308 608	39.395 4312	11.577 9208	.000 644 3299
1553	2 411 809	3 745 539 377	39.408 1210	11.580 4069	.000 643 9150
1554	2 414 916	3 752 779 464	39.420 8067	11.582 8919	.000 643 5006
1555	2 418 025	3 760 028 875	39.433 4883	11.585 3759	.000 643 0868
1556	2 421 136	3 767 287 616	39.446 1658	11.587 8588	.000 642 6735
1557	2 424 249	3 774 555 693	39.458 8393	11.590 3407	.000 642 2608
1558	2 427 364	3 781 833 112	39.471 5087	11.592 8215	.000 641 8485
1559	2 430 481	3 789 119 879	39.484 1740	11.595 3013	.000 641 4368
1560	2 433 600	3 796 416 000	39.496 8353	11.597 7799	.000 641 0256

Number.	Squares.	Cubes.	$\sqrt{}$ Roots.	$\sqrt[3]{}$ Roots.	Reciprocals.
1561	2 436 721	3 803 721 481	39.509 4925	11.600 2576	.000 640 6150
1562	2 439 844	3 811 036 328	39.522 1457	11.602 7342	.000 640 2049
1563	2 442 969	3 818 360 547	39.534 7948	11.605 2097	.000 639 7953
1564	2 446 096	3 825 641 444	39.547 4399	11.607 6841	.000 639 3862
1565	2 449 225	3 833 037 125	39.560 0809	11.610 1575	.000 638 9776
1566	2 452 356	3 840 389 496	39.572 7179	11.612 6299	.000 638 5696
1567	2 455 489	3 847 751 263	39.585 3508	11.615 1012	.000 638 1621
1568	2 458 624	3 855 123 432	39.597 9797	11.617 5715	.000 637 7551
1569	2 461 761	3 862 503 009	39.610 6046	11.620 0407	.000 637 3486
1570	2 464 900	3 869 883 000	39.623 2255	11.622 5088	.000 636 9427
1571	2 468 041	3 877 292 411	39.635 8424	11.624 9759	.000 636 5372
1572	2 471 184	3 884 701 248	39.648 4552	11.627 4420	.000 636 1323
1573	2 474 329	3 892 119 157	39.661 0640	11.629 9070	.000 635 7279
1574	2 477 476	3 899 547 224	39.673 6688	11.632 3710	.000 635 3240
1575	2 480 625	3 906 984 375	39.686 2696	11.634 8339	.000 634 9206
1576	2 483 776	3 914 430 976	39.698 8665	11.637 2957	.000 634 5178
1577	2 486 929	3 921 887 033	39.711 4593	11.639 7566	.000 634 1154
1578	2 490 084	3 929 352 552	39.724 0481	11.642 2164	.000 633 7136
1579	2 493 241	3 936 827 539	39.736 6329	11.644 6751	.000 633 3122
1580	2 496 400	3 944 312 000	39.749 2138	11.647 1329	.000 632 9114
1581	2 499 561	3 951 805 941	39.761 7907	11.649 5895	.000 632 5111
1582	2 502 724	3 959 309 368	39.774 3636	11.652 0452	.000 632 1113
1583	2 505 889	3 966 822 287	39.786 9325	11.654 4998	.000 631 7119
1584	2 509 056	3 974 344 704	39.799 4976	11.656 9534	.000 631 3131
1585	2 512 225	3 981 876 625	39.812 0585	11.659 4059	.000 630 9148
1586	2 515 396	3 989 418 056	39.824 6155	11.661 8574	.000 630 5170
1587	2 518 569	3 996 969 003	39.837 1686	11.664 3079	.000 630 1197
1588	2 521 744	4 004 529 472	39.849 7177	11.666 7574	.000 629 7229
1589	2 524 921	4 012 099 469	39.862 2628	11.669 2058	.000 629 3266
1590	2 528 100	4 019 679 000	39.874 8040	11.671 6532	.000 628 9308
1591	2 531 281	4 027 268 071	39.887 3413	11.674 0996	.000 628 5355
1592	2 534 464	4 034 866 688	39.899 8747	11.676 5449	.000 628 1407
1593	2 537 649	4 042 474 857	39.912 4041	11.678 9892	.000 627 7464
1594	2 540 836	4 050 092 584	39.924 9295	11.681 4325	.000 627 3526
1595	2 544 025	4 057 719 875	39.937 4511	11.683 8748	.000 626 9592
1596	2 547 216	4 065 356 736	39.949 9687	11.686 3161	.000 626 5664
1597	2 550 409	4 073 003 173	39.962 4824	11.688 7563	.000 626 1741
1598	2 553 604	4 080 659 192	39.974 9922	11.691 1955	.000 625 7822
1599	2 556 801	4 088 324 799	39.987 4980	11.693 6337	.000 625 3909
1600	2 560 000	4 096 000 000	40.000 0000	11.696 0709	.000 625 0000

The use of the table of powers and roots may be extended far beyond its apparent limits by the observance of the following rules

Remembering that the extraction of the square root of a number is simply the separating it into two equal factors, we have to extract the square root of any whole number and decimal, when the whole number is within the limits of the table simply find the square root of the whole number in the table and divide the given number and decimal by this root. The quotient will be another factor, *very nearly* equal to the required root. Add the divisor and the quotient together and divide by two, and *the result will be the true root* to a very close degree of approximation.

These tables, together with those of Metric System and Logarithms have *been taken by permission from Suplee's* "Reference Book."

LOGARITHMS.

There are four fundamental rules for operations with powers:

$$a^m \,.\, a^n = a^{m+n}.$$

That is, the product of any two powers of a number is equal to the number raised to a power whose exponent is the *sum* of the exponents of the two factors.

$$\frac{a^m}{a^n} = a^{m-n}.$$

Or, the quotient of two powers is equal to the number raised to a power whose exponent is the *difference* of the exponents of divisor and dividend.

$$(a^n)^m = a^{mn}.$$

Or, any power may be raised to a higher power by multiplying the two exponents.

$$\sqrt[n]{a^m} = a^{\frac{m}{n}}.$$

Or, any root of any power may be extracted by *dividing* the exponent by the index of the root.

If we take any number, such as 2, and use it as the base of a geometrical series, we will see that the exponents form an arithmetical series. Thus, the exponent of 1 = 0, of 2 = 1, of 4 = 2, of 8 = 3, etc.; or, proceeding, we may arrange the following little table:

Powers.	Exponents.	Powers.	Exponents.	Powers.	Exponents.
1	0	1024	10	1048576	20
2	1	2048	11	2097152	21
4	2	4096	12	4194304	22
8	3	8192	13	8388608	23
16	4	16384	14	16777216	24
32	5	32768	15		
64	6	65536	16		
128	7	131072	17		
256	8	262144	18		
512	9	524288	19		

Suppose now we wish to multiply 128 by 512, we see that $128 = 2^7$ and $512 = 2^9$; hence, $128 \times 512 = 2^{7-9} = 2^{16}$, and in the table, opposite the exponent 16, we find the power 65536, which is the product of the two factors, obtained by the simple addition of the exponents.

Again, $$\frac{512}{128} = \frac{2^9}{2^7} = 2^{9-7} = 2^2 = 4.$$

To raise a number to a power, such as 16 to the fifth power, we have $16 = 2^4$ and $(2^4)^5 = 2^{20} = 1048576$.

Again, the seventh root of 2097152 is formed as follows:

$$2097152 = 2^{21} \text{ and } \sqrt[7]{2^{21}} = 2^{\frac{21}{7}} = 2^3 = 8.$$

In the small table of the powers of 2 given above there are many gaps, because only those powers which have *whole* exponents are given. For all the numbers between 16 and 32, for example, the exponents will be decimals, and will be greater than 4 and less than 5, etc. In practice, the base used is not 2, but 10, and all the intermediate exponents have been computed to many decimals, these forming a table of logarithms.

Table of Logarithms of Numbers.

Pages 82 to 104 give the *mantissas*, or decimal portions of the logarithms, of all whole numbers from 1 to 10009. The *characteristics*, or whole numbers, which, with these decimals, form the complete logarithms, are found as follows:

The logarithm of 1 = 0, of 10 = 1, of 100 = 2, of 1000 = 3, etc.; hence, the logarithm of any number between 100 and 1000 must lie between 2 and 3, and be greater than 2 and less than 3, and so for any number. Therefore we have the rule that the whole portion of a logarithm of any number is one less than there are figures in the number. The decimal portion for any number below 10009 is taken directly from the table. Thus,

$$\log. 365 = 2.56229,$$

the decimal portion, 56229, being found directly opposite 365 in the table, and the whole portion being 2, or 1 less than the number of places in 365.

In like manner we have

$$\log. 36.5 = 1.56229,$$
$$\log. 3.65 = 0.56229.$$

The mantissa, or decimal portion, is always positive, but the characteristic is negative when the number is less than unity. Thus,

$$\log. 0.365 = \bar{1}.56229,$$
$$\log. 0.0365 = \bar{2}.56229,$$
$$\log. 0.00365 = \bar{3}.56229,$$

the minus being placed *over* the characteristic to show that it applies to that portion only, and not to the mantissa.

If the given number has more than three places, the mantissa is found in the body of the table. Thus, the logarithm of 1873 = 3.27254, the figures 0.27 being found opposite 187, and the 254 on the same horizontal line under 3.

If the last three figures of the mantissa are preceded by an asterisk, the first two figures are to be taken from the next line *below*, in the first column. Thus,

$$\log. 3897 = 3.59073,$$

in which, opposite 389, we find 58, and then, passing on under 7, we find *073, the asterisk indicating that we are to go one line below, taking out 59, not 58, for the first two figures of the mantissa, giving us 0.59073, as above.

The table, as will be seen, enables the logarithm of any number of *four* places to be taken out at once. If the number of which the logarithm is required has more than four places, the logarithm can be found from the table, as follows:

In the column at the extreme right of each page, under the heading P. P. (Proportional Parts), will be found in the black figures the *differences* between any logarithm and the next succeeding logarithm for the adjoining portions of the table. The smaller figures in the same column form little multiplication tables, in which these differences are multiplied by 0.1, 0.2, 0.3, etc.

The use of these proportional parts and their decimal parts is best shown by actual example. Suppose it is desired to find the logarithm of 18702. Opposite 187 and under 0 in the table we find the mantissa, 0.27184. The proportional part, or difference at this point between one logarithm and the next, is 23, or, in other words, there is a difference of 23 between the last two figures of the logarithm of 1870 and 1871. For 0.1 difference in the number, the difference in the logarithms would be 2.3; for 0.2, it would be 4.6, etc., as shown in the small table under 23 in the column P. P. For 2 points additional, therefore, we simply add 4.6 to the logarithm of 1870, and we have the logarithm of 18702. Thus,

$$\begin{aligned} \log. 1870 &= 0.27184 \\ \text{p. p. for } 2 &= \quad\quad\;\; 4.6 \\ \log. 18702 &= \overline{4.271886}, \text{ or} \\ & \quad\; 4.27189 \end{aligned}$$

Again, let it be required to find the logarithm of 35.797.

log. 35.79 = 1.55376		p. p. = 12
p. p. for 7 =	8.4	
log. 35.797 = 1.553844		

If the given number has six or more figures the method is the same, except that the proportional part is reduced one-tenth for each additional figure. Thus, the logarithm of 3725.96 is found as follows:

log. 3725 = 3.57113		p. p. = 11
p. p. for 9 =	9.9	
p. p. for 6 =	0.66	
log. 3725.96 = 3.5712356, or 3.57124		

The operation of finding the number corresponding to a given logarithm is the reverse of the preceding. Thus, the number corresponding to the logarithm 2.73924 is found as follows:

In the table the next smaller logarithm is

	73918, and its number		= 584500
The given log. =	73924		..
and the difference =	6		..
The nearest difference in the table =	5.6	= corresponding to	7
Subtracting	0.4	corresponding to	5
		Hence, the number is	584575

Since the characteristic = 2, there must be one more place before the decimal point; hence,

log. 2.73924 = num. 584.575

Num 100 to 139. Log. 000 to 145.

N	L	0	1	2	3	4	5	6	7	8	9
100	00	000	043	087	130	173	217	260	303	346	389
101		432	475	518	561	604	647	689	732	775	817
102		860	903	945	988	*030	*072	*115	*157	*199	*242
103	01	284	326	368	410	452	494	536	578	620	662
104		703	745	787	828	870	912	953	995	*036	*078
105	02	119	160	202	243	284	325	366	407	449	490
106		531	572	612	653	694	735	776	816	857	898
107		938	979	*019	*060	*100	*141	*181	*222	*262	*302
108	03	342	383	423	463	503	543	583	623	663	703
109		743	782	822	862	902	941	981	*021	*060	*100
110	04	139	179	218	258	297	[redacted]	376	415	454	493
111		532	571	610	650	689	727	766	805	844	883
112		922	961	999	*038	*077	*115	*154	*192	*231	*269
113	05	308	346	385	423	461	500	538	576	614	652
114		690	729	767	805	843	881	918	956	994	*032
115	06	070	108	145	183	221	258	296	333	371	408
116		446	483	521	558	595	633	670	707	744	781
117		819	856	893	930	967	*004	*041	*078	*115	*151
118	07	188	225	262	298	335	372	408	445	482	518
119		555	591	628	664	700	737	773	809	846	882
120		918	954	990	*027	*063	*099	*135	*171	*207	*243
121	08	279	314	350	386	422	458	493	529	565	600
122		636	672	707	743	778	814	849	884	920	955
123		991	*026	*061	*096	*132	*167	*202	*237	*272	*307
124	[redacted]	342	377	412	447	482	517	552	587	621	656
125		691	726	760	795	830	864	899	934	968	*003
126	10	037	072	106	140	175	209	243	278	312	346
127		380	415	449	483	517	551	585	619	653	687
128		721	755	789	823	857	890	924	958	992	*025
129	11	059	093	126	160	193	227	261	294	327	361
130		394	428	461	494	528	561	594	628	661	694
131		727	760	793	826	860	893	926	959	992	*024
132	12	057	090	123	156	189	222	254	287	320	352
133		385	418	450	483	516	548	581	613	646	678
134		710	743	775	808	840	872	905	937	969	*001
135	13	033	066	098	130	162	194	226	258	290	322
136		354	386	418	450	481	513	545	577	609	640
137		672	704	735	767	799	830	862	893	925	956
138		988	*019	*051	*082	*114	*145	*176	*208	*239	*270
139	14	301	333	364	395	426	457	489	520	551	582
140		*613*	*644*	*675*	*706*	*737*	*768*	*799*	*829*	*860*	*891*

N L 0 1 2 3 4 5 6 7 8 9

P. P.

	44	43	42	41	[redacted]	39	38	37	36	35
1	4.4	4.3	4.2	4.1	4.0	3.9	3.8	3.7	3.6	3.5
2	8.8	8.6	8.4	8.2	8.0	7.8	7.6	7.4	7.2	7.0
3	13.2	12.9	12.6	12.3	12.0	11.7	11.4	11.1	10.8	10.5
4	17.6	17.2	16.8	16.4	16.0	15.6	15.2	14.8	14.4	14.0
5	22.0	21.5	21.0	20.5	20.0	19.5	19.0	18.5	18.0	17.5
6	26.4	25.8	25.2	24.6	24.0	23.4	22.8	22.2	21.6	21.0
7	30.8	30.1	29.4	28.7	28.0	27.3	26.6	25.9	25.2	24.5
8	35.2	34.4	33.6	32.8	32.0	31.2	30.4	29.6	28.8	28.0
9	39.6	38.7	37.8	36.9	36.0	35.1	34.2	33.3	32.4	31.5

P. P.

Num. 140 to 179. Log. 146 to 255.

N	L.	0	1	2	3	4	5	6	7	8	9
140	14	613	644	675	706	737	768	799	829	860	891
141		922	953	983	*014	*045	*076	*106	*137	*168	*198
142	15	229	259	290	320	351	381	412	442	473	503
143		534	564	594	625	655	685	715	746	776	806
144		836	866	897	927	957	987	*017	*047	*077	*107
145	16	137	167	197	227	256	286	316	346	376	406
146		435	465	495	524	554	584	613	643	673	702
147		732	761	791	820	[redacted]	879	909	938	967	997
148	17	026	056	085	114	143	173	202	231	260	289
149		319	348	377	406	435	464	493	522	551	580
150		609	638	667	696	725	754	782	811	840	869
151		898	926	955	984	*013	*041	*070	*099	*127	*156
152	18	184	213	241	270	298	327	355	384	412	441
153		[redacted]	498	526	554	583	611	639	667	696	724
154		752	780	808	837	865	[redacted]	921	949	977	*005
155	19	033	061	089	117	145	173	201	229	257	285
156		312	340	368	396	424	451	479	507	535	562
157		590	618	645	673	700	728	756	783	811	838
158		866	893	921	918	976	*003	*030	[redacted]	*085	*112
159	20	140	167	194	222	249	276	303	330	358	385
160		412	439	466	493	520	548	575	602	629	656
161		683	710	737	763	790	817	844	871	898	925
162		952	978	*005	*032	*059	*085	*112	*139	*165	*192
163	21	219	245	272	299	325	352	378	405	431	458
164		484	511	537	564	590	617	643	669	696	722
165		748	775	801	827	854	880	906	932	958	985
166	22	011	037	063	089	115	141	167	194	220	246
167		272	298	324	350	376	401	427	453	479	505
168		531	557	583	608	634	660	686	712	737	763
169		789	814	840	866	891	917	943	968	994	*019
170	23	045	070	096	121	147	172	198	223	249	274
171		300	325	350	376	401	426	452	477	502	528
172		553	578	603	629	654	679	704	729	754	779
173		805	830	855	880	905	930	955	980	*005	*030
174	24	055	080	105	130	155	180	204	229	254	279
175		[illegible]	329	353	378	403	428	452	477	502	527
176		[illegible]	576	601	625	650	674	699	724	748	773
177		797	822	846	871	895	920	944	969	993	*018
178	25	042	066	091	115	139	164	188	212	237	261
179		285	310	334	358	382	406	431	455	479	503
180		527	551	575	600	624	648	672	696	720	744
N	L.	0	1	2	3	4	5	6	7	8	9

P. P.

	34	33
1	3.4	3.3
2	6.8	6.6
3	10.2	9.9
4	13.6	13.2
5	17.0	16.5
6	20.4	19.8
7	23.8	23.1
8	27.2	26.4
9	30.6	29.7

	32	31
1	3.2	3.1
2	6.4	6.2
3	9.6	9.3
4	12.8	12.4
5	16.0	15.5
6	19.2	18.6
7	22.4	21.7
8	25.6	24.8
9	28.8	27.9

	30	29
1	3.0	2.9
2	6.0	5.8
3	9.0	8.7
4	12.0	11.6
5	15.0	14.5
6	18.0	17.4
7	21.0	20.3
8	24.0	23.2
9	27.0	26.1

	28	27
1	2.8	2.7
2	5.6	5.4
3	8.4	8.1
4	11.2	10.8
5	14.0	13.5
6	16.8	16.2
7	19.6	18.9
8	22.4	21.6
9	25.2	24.3

	26	25
1	2.6	2.5
2	5.2	5.0
3	7.8	7.5
4	10.4	10.0
5	13.0	12.5
6	15.6	15.0
7	18.2	17.5
8	20.8	20.0
9	23.4	22.5

Num. 80 to 219. Log. 255 to 342.

N	L.	0	1	2	3	4	5	6	7	8	9
180	25	527	551	575	600	624	648	672	696	720	744
181		768	792	816	840	864	888	912	935	959	983
182	26	007	031	055	079	102	126	150	174	198	221
183		245	269	293	316	340	364	387	411	435	458
184		482	505	529	553	576	600	623	647	670	694
185		717	741	764	788	811	834	858	881	905	928
186		951	975	998	*021	*045	*068	*091	*114	*138	*161
187	27	184	207	231	254	277	300	323	346	370	393
188		416	439	462	485	508	531	554	577	600	623
189		646	669	692	715	738	761	784	807	830	852
190		875	898	921	944	967	989	*012	*035	*058	*081
191	28	103	126	149	171	194	217	240	262	285	307
192		330	353	375	398	421	443	466	488	511	533
193		556	578	601	623	646	668	691	713	735	758
194		780	803	825	847	870	892	914	937	959	981
195	29	003	026	048	070	092	115	137	159	181	203
196		226	248	270	292	314	336	358	380	403	425
197		447	469	491	513	535	557	579	601	623	645
198		667	688	710	732	754	776	798	820	842	863
199		885	907	929	951	973	994	*016	*038	*060	*081
200	[redacted]	103	125	146	168	190	211	233	255	276	298
201		320	341	363	384	406	428	449	471	492	514
202		535	557	578	600	621	643	664	685	707	728
203		750	771	792	814	835	856	878	899	920	942
204		963	984	*006	*027	*048	*069	*091	*112	*133	*154
205	31	175	197	218	239	260	281	302	323	345	366
206		387	408	429	450	471	492	513	534	555	576
207		597	618	639	660	681	702	723	744	765	785
208		806	827	848	869	890	911	931	952	973	994
209	32	015	035	056	077	098	118	139	160	181	201
210		222	243	263	284	305	325	346	366	387	408
211		428	449	469	490	510	531	552	572	593	613
212		634	654	675	695	715	736	756	777	797	818
213		[redacted]	858	879	899	919	940	960	980	*001	*021
214	33	041	062	082	102	122	143	163	183	203	224
215		244	264	284	304	325	345	365	385	405	425
216		445	465	486	506	526	546	566	586	606	626
217		646	666	686	706	726	746	766	786	806	826
218		846	866	885	905	925	945	965	985	*005	*025
219	34	044	064	084	104	124	143	163	183	203	223
220		242	262	282	301	321	341	361	380	400	420
N	L	0	1	2	3	4	5	6	7	8	9

P. P.

	24	23	22	21	[redacted]	19
1	2.4	2.3	2.2	2.1	2.0	1.9
2	4.8	4.6	4.4	4.2	4.0	3.8
3	7.2	6.9	6.6	6.3	6.0	5.7
4	9.6	9.2	8.8	8.4	8.0	7.6
5	12.0	11.5	11.0	10.5	10.0	9.5
6	14.4	13.8	13.2	12.6	12.0	11.4
7	16.8	16.1	15.4	14.7	14.0	13.3
8	19.2	18.4	17.6	16.8	16.0	15.2
9	21.6	20.7	19.8	18.9	18.0	17.1

Num. 220 to 259. Log. 342 to 414.

N	L	0	1	2	3	4	5	6	7	8	9
[redacted]	34	242	262	283	301	321	341	361	380	400	420
221		439	459	479	498	518	537	557	577	596	616
222		635	655	674	694	713	733	753	772	792	811
223		830	850	869	889	908	928	947	967	986	*006
224	35	025	044	064	083	102	122	141	160	180	199
225		218	238	257	276	295	315	334	353	372	392
226		411	430	449	468	488	507	526	545	564	583
227		603	622	641	660	679	698	717	736	755	774
228		793	813	832	851	870	889	908	927	946	965
229		984	*003	*021	*040	*059	*078	*097	*116	*135	*154
230	36	173	192	211	229	248	267	286	305	324	342
231		361	380	399	418	436	455	474	493	511	530
232		549	568	586	605	624	642	661	680	698	717
233		736	754	773	791	810	829	847	866	884	903
234		922	940	959	977	996	*014	*033	*051	[redacted]	
235	37	107	125	144	162	181	199	218	236	254	273
236		291	310	328	346	365	38	401	420	438	457
237		475	493	511	530	548	566	5	603	621	639
238		658	676	694	712	731	749	767	785	803	822
239		840	858	876	894	912	931	949	967	985	*003
240	38	021	039	057	075	093	112	130	148	166	184
241		202	220	238	256	274	292	310	328	346	364
242		382	399	417	435	453	471	489	507	525	543
243		561	578	596	614	632	650	668	686	703	721
244		739	757	775	792	810	828	846	863	881	899
245		917	934	952	970	987	*005	*023	*041	*058	*076
246	39	094	111	129	146	164	182	199	217	235	252
247		270	287	305	322	340	358	375	393	410	428
248		445	463	480	498	515	533	550	568	585	602
249		620	637	655	672	690	707	724	742	759	777
250		794	811	829	846	863	881	898	915	933	950
251		967	985	*002	*019	*037	*054	*071	*088	*106	*123
252	40	140	157	175	192	209	226	243	261	278	295
253		312	329	346	364	381	398	415	432	449	466
254		483	500	518	535	552	569	586	603	620	637
255		654	671	688	705	722	739	756	773	790	807
256		824	841	858	875	892	909	926	943	960	976
257		993	*010	*027	*044	*061	*078	*095	*111	*128	*145
258	41	162	179	196	212	229	246	263	280	296	313
259		330	347	363	380	397	414	430	447	464	481
260		497	514	531	547	564	581	597	614	631	647
N	L	0	1	2	3	4	5	6	7	8	9

P. P.

	20	19	18	17
1	2.0	1.9	1.8	1.7
2	4.0	3.8	3.6	3.4
3	6.0	5.7	5.4	5.1
4	8.0	7.6	7.2	6.8
5	10.0	9.5	9.0	8.5
6	12.0	11.4	10.8	10.2
7	14.0	13.3	12.6	11.9
8	16.0	15.2	14.4	13.6
9	18.0	17.1	16.2	15.3

Num. 260 to 299. Log. 414 to 476.

[illegible]	L.	0	1	2	3	4	5	6	7	8	9
260	41	497	514	531	547	564	581	597	614	631	647
261		664	681	697	714	731	747	764	780	797	814
262		830	847	863	880	896	913	929	946	963	979
263		996	*012	*029	*045	*062	*078	*095	*111	*127	144
264	[illegible]	160	177	193	210	226	243	259	275	292	308
265		325	341	357	374	390	406	423	439	455	472
266		488	504	521	537	553	570	586	602	619	635
267		651	667	684	700	716	732	749	765	781	797
268		813	830	846	862	878	894	911	927	943	959
269		975	991	*008	*024	*040	*056	*072	*088	*104	*120
270	43	136	152	169	185	201	217	233	249	265	281
271		297	313	329	345	361	377	393	409	425	441
272		457	473	489	505	521	537	553	569	584	600
273		616	632	648	664	680	696	712	727	743	759
274		775	791	807	823	838	854	870	886	902	917
275		933	949	965	981	996	*012	*028	*044	*059	*075
276	44	091	107	122	138	154	170	185	201	217	232
277		248	264	279	295	311	326	342	358	373	389
278		404	420	436	451	467	483	498	514	529	545
279		560	576	592	607	623	638	654	669	685	700
280		716	731	747	762	778	793	809	824	840	855
281		871	886	902	917	932	948	963	979	994	*010
282	45	025	040	056	071	086	102	117	133	148	163
283		179	194	209	225	240	255	271	286	301	317
284		332	347	362	378	[illegible]	408	423	439	454	469
285		484	500	515	530	545	561	576	591	606	621
286		637	652	667	682	697	712	728	743	758	773
287		788	803	818	834	849	864	879	894	909	924
288		939	954	969	984	*000	*015	*030	*045	*060	*075
289	46	090	105	120	135	150	165	180	195	210	225
290		240	255	270	285	300	315	330	345	359	374
291		389	404	419	434	449	464	479	494	509	523
292		538	553	568	583	598	613	627	642	657	672
293		687	702	716	731	746	761	776	790	805	820
294		835	850	864	879	894	909	923	938	953	967
295		982	997	*012	*026	*041	*056	*070	*085	*100	*114
296	47	129	144	159	173	188	202	217	232	246	261
297		276	290	305	319	334	349	363	378	392	407
298		422	436	451	465	480	494	509	524	538	553
299		567	582	596	611	625	640	654	669	683	698
300		712	727	741	756	770	784	799	813	828	842
N	*L*	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*

P. P.

	17	16	15
1	1.7	1.6	1.5
2	3.4	3.2	3.0
3	5.1	4.8	4.5
4	6.8	6.4	6.0
5	8.5	8.0	7.5
6	10.2	9.6	9.0
7	11.9	11.2	10.5
8	13.6	12.8	12.0
9	15.3	14.4	13.5

Num. 300 to 339. Log. 477 to 531

N	L.	0	1	2	3	4	5	6	7	8	9
300	47	712	727	741	756	770	784	799	813	828	842
301		857	871	885	900	914	929	943	958	972	986
302	48	001	015	029	044	058	073	087	101	116	130
303		144	159	173	187	202	216	230	244	259	273
304		287	302	316	330	344	359	373	387	401	416
305		430	444	458	473	487	501	515	530	544	558
306		572	586	601	615	629	643	657	671	686	700
307		714	728	742	756	770	785	799	813	827	841
308		855	869	883	897	911	926	940	954	968	982
309		996	*010	*024	*038	*052	*066	*080	*094	*108	*122
310	49	136	150	164	178	192	206	220	234	248	262
311		276	290	304	318	332	346	360	374	[illegible]	402
312		415	429	443	457	471	485	499	513	527	541
313		554	568	582	596	610	624	638	651	685	679
314		693	707	721	784	748	762	776	790	803	817
315		[illegible]	845	859	872	[illegible]	900	914	927	941	955
316		969	982	996	*010	*024	*037	*051	*065	*079	*092
317	50	106	120	133	147	161	174	188	202	215	229
318		243	256	270	284	297	311	325	338	352	365
319		379	393	406	420	433	447	461	474	[illegible]	501
320		515	529	542	556	569	583	596	610	623	637
321		651	664	678	691	705	718	732	745	759	772
322		786	799	813	826	840	853	866	880	893	907
323		920	934	947	961	974	987	*001	*014	*028	*041
324	51	055	068	081	095	108	121	135	148	162	175
325		188	202	215	228	242	255	268	282	295	308
326		322	335	348	362	375	388	402	415	428	441
327		455	468	481	495	508	521	534	548	561	574
328		587	601	614	627	640	651	667	680	693	706
329		720	733	746	769	772	786	799	812	825	838
330		851	865	878	891	904	917	930	943	957	970
331		983	996	*009	*022	*035	*048	*061	*075	*088	*101
332	52	114	127	140	153	166	179	192	205	218	231
333		244	257	270	284	297	310	323	336	349	362
334		375	388	401	414	427	440	453	466	479	492
335		504	517	530	543	556	569	582	595	608	621
336		634	647	660	673	686	699	711	724	737	750
337		763	776	789	802	815	827	840	853	866	879
338		892	905	917	930	943	956	969	982	994	*007
339	53	020	033	046	058	071	084	097	110	122	135
340		148	161	173	186	199	212	224	237	250	263
N	L.	0	1	2	3	4	5	6	7	8	9

P. P.

	14
1	1.4
2	2.8
3	4.2
4	5.6
5	7.0
6	8.4
7	9.8
8	11.2
9	12.6

	[illegible]
1	1.3
2	2.6
3	3.9
4	5.2
5	6.5
6	7.8
7	9.1
8	10.4
9	11.7

	12
1	1.2
2	2.4
3	3.6
4	4.8
5	6.0
6	7.2
7	8.4
8	9.6
9	10.8

Num. 340 to 379. Log. 531 to 579.

N	L	0	1	2	[redacted]	4	5	6	7	8	9
340	53	148	161	173	186	199	212	224	237	250	263
341		275	288	301	314	326	339	352	364	377	390
342		403	415	428	441	453	466	479	491	504	517
343		529	542	555	567	580	593	605	618	631	643
344		656	668	681	694	706	719	732	744	757	769
345		782	794	[redacted]	[redacted]	[redacted]	845	857	870	882	895
346		908	920	933	945	958	970	983	995	*008	*020
347	54	033	045	058	070	083	095	108	120	133	145
348		158	170	183	195	208	220	233	245	258	270
349		283	295	307	320	332	345	357	370	382	394
350		407	419	432	444	456	469	481	494	506	518
351		531	543	555	568	580	593	605	617	630	642
352		654	667	679	691	704	716	728	741	753	765
353		777	790	802	814	827	839	851	864	876	888
354		900	913	925	937	949	962	974	986	998	*011
355	55	023	035	047	[redacted]	072	084	096	108	121	133
356		145	157	169	182	194	206	218	230	242	255
357		267	279	291	303	315	328	340	352	364	376
358		388	400	413	425	437	449	461	473	485	497
359		509	522	534	546	558	570	582	594	606	618
360		630	642	654	666	678	691	703	715	727	739
361		751	763	775	787	799	811	823	835	847	859
362		871	883	895	907	919	931	943	955	967	979
363		991	*003	*015	*027	*038	*050	*062	*074	*086	*098
364	56	110	122	134	146	158	170	182	194	205	217
365		229	241	253	265	277	289	301	312	324	336
366		348	360	372	384	396	407	419	431	443	455
367		467	478	490	502	514	526	538	549	561	573
368		585	597	608	620	632	644	656	667	679	691
369		703	714	726	738	750	761	773	785	797	808
370		820	832	844	855	867	879	891	902	914	926
371		937	949	961	972	984	996	*008	*019	*031	*043
372	57	054	066	078	[redacted]	101	113	124	136	148	159
373		171	183	194	206	217	229	241	252	264	276
374		287	299	310	322	334	345	357	368	380	392
375		[redacted]	415	426	438	449	461	473	484	496	507
376		519	530	542	553	565	576	588	600	611	623
377		634	646	657	669	680	692	703	715	726	738
378		749	761	772	784	795	807	818	830	841	852
379		864	875	887	898	910	921	933	944	955	967
380		978	990	*001	*013	*024	*035	*047	*058	*070	*081
N	L	0	1	2	3	4	5	6	7	8	9

P. P.

	13
1	1.3
2	2.6
3	3.9
4	5.2
5	6.5
6	7.8
7	9.1
8	10.4
9	11.7

	12
1	1.2
2	2.4
3	3.6
4	4.8
5	6.0
6	7.2
7	8.4
8	9.6
9	10.8

	11
1	1.1
2	2.2
3	3.3
4	4.4
5	5.5
6	6.6
7	7.7
8	8.8
9	9.9

P. P.

Num. 380 to 4 9. Log. 579 to 623.

N	L.	0	1	2	3	4	5	6	7	8	9
380	57	978	990	*001	*013	*024	*035	*047	*058	[illegible]	*081
381	58	092	104	115	127	138	149	161	172	184	195
382		206	218	229	240	252	263	274	286	297	309
383		320	331	343	354	365	377	388	399	410	422
384		433	444	456	467	478	490	501	512	524	535
385		546	557	569	580	591	602	614	625	636	647
386		659	670	681	692	704	715	726	737	749	760
387		771	782	794	805	816	827	838	850	861	872
388		883	894	906	917	928	939	950	961	973	984
389		995	*006	*017	*028	*040	*051	*062	*073	*084	*095
390	59	106	118	129	140	151	162	173	184	195	207
391		218	229	240	251	262	273	284	295	306	318
392		329	340	351	362	373	384	395	406	417	428
393		439	450	461	472	483	494	506	517	528	539
394		550	561	572	583	594	605	616	627	638	649
395		660	671	682	693	704	715	726	737	748	759
396		770	780	791	802	813	824	835	846	857	868
397		879	890	901	912	923	934	945	956	966	977
398		988	999	*010	*021	*032	*043	*054	*065	*076	*086
399	60	097	108	119	130	141	152	163	173	184	195
400		206	217	228	239	249	260	271	282	[illegible]	304
401		314	325	336	347	358	369	379	390	401	412
402		423	433	444	455	466	477	487	498	509	520
403		531	541	552	563	574	584	595	606	617	627
404		638	649	660	670	681	692	703	713	724	735
405		746	756	767	778	788	799	810	821	831	842
406		853	863	874	885	895	906	917	927	938	949
407		959	970	981	991	*002	*013	*023	*034	*045	*055
408	61	066	077	087	098	109	119	130	140	151	162
409		172	183	194	204	215	225	236	247	257	268
410		278	289	300	310	321	331	342	352	363	374
411		384	395	405	416	426	437	448	458	469	479
412		490	500	511	521	532	542	553	563	574	584
413		595	606	616	627	637	648	658	669	679	690
414		700	711	721	731	742	752	763	773	784	794
415		805	815	826	836	847	857	868	878	888	899
416		909	920	930	941	951	962	972	982	993	*003
417	62	014	024	034	045	055	066	076	086	097	107
418		118	128	138	149	159	170	180	190	201	211
419		221	232	242	252	263	273	284	294	304	315
420		325	335	346	356	366	377	387	397	408	418
N	L	0	1	2	3	4	5	6	7	8	9

P.P.

	11
1	1.1
2	2.2
3	[illegible]
4	4.4
5	5.5
6	6.6
7	7.7
8	8.8
9	9.9

	10
1	1.0
2	2.0
3	3.0
4	4.0
5	5.0
6	6.0
7	7.0
8	8.0
9	9.0

P.P.

Num. 420 to 459. Log. 623 to 662.

N	L	0	1	2	3	4	5	6	7	8	9
420	62	325	335	346	356	366	377	387	397	408	418
421		428	439	449	459	469	480	490	500	511	521
422		531	542	552	562	572	583	593	603	613	624
423		634	644	655	665	675	685	696	706	716	726
424		737	747	757	767	778	788	798	808	818	829
425		839	849	859	870	880	890	900	910	921	931
426		941	951	961	972	982	992	*002	*012	*022	*033
427	63	043	053	063	073	083	094	104	114	124	134
428		144	155	165	175	185	195	[illegible]	215	225	236
429		246	256	266	276	286	296	306	317	327	337
430		347	357	367	377	387	397	407	417	428	438
431		448	458	468	478	488	498	508	518	528	538
432		548	558	568	579	589	599	609	619	629	639
433		649	659	669	679	689	699	709	719	729	739
434		749	759	769	779	789	799	809	819	829	839
435		849	859	869	879	889	899	909	919	929	939
436		949	959	969	979	988	998	*008	*018	*028	*038
437	64	048	058	068	078	088	098	108	118	128	137
438		147	157	167	177	187	197	207	217	227	237
439		246	256	266	276	286	296	306	316	326	335
440		345	355	365	375	385	395	404	414	424	434
441		444	454	464	473	483	493	503	513	523	532
442		542	552	562	572	582	591	601	611	621	631
443		640	650	660	670	680	689	699	709	719	729
444		738	748	758	768	777	787	797	807	816	826
445		836	846	856	865	875	885	895	[illegible]	914	924
446		933	943	953	963	972	982	992	*002	*011	*021
447	65	031	040	050	060	070	079	[illegible]	099	108	118
448		128	137	147	157	167	176	186	196	205	215
449		225	234	244	254	263	273	283	292	302	312
450		321	331	341	350	360	369	379	[illegible]	398	408
451		418	427	437	447	456	466	475	485	495	504
452		514	523	533	543	552	562	571	581	591	600
453		610	619	629	639	648	658	667	677	686	696
454		706	715	725	734	744	753	763	772	782	792
455		801	811	820	830	839	849	858	868	877	887
456		896	906	916	925	935	944	954	963	973	982
457		992	*001	*011	*020	*030	*039	*049	*058	*068	*077
458	66	087	096	106	115	124	134	143	153	162	172
459		181	191	[illegible]	210	219	229	238	247	257	266
460		*276*	285	295	304	314	323	332	342	351	361
N	*L*	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*

P. P.

	10
1	1.0
2	2.0
3	3.0
4	[illegible]
5	5.0
6	6.0
7	7.0
8	8.0
9	9.0

	[illegible]
1	0.9
2	1.8
3	2.7
4	3.6
5	4.5
6	5.4
7	6.3
8	7.2
9	8.1

Num. 450 to 499. Log. 653 to 698.

N	L.	0	1	2	3	4	5	6	7	8	9
460	66	276	285	295	304	314	323	332	342	351	361
461		370	380	389	398	408	417	427	436	445	455
462		464	474	483	492	502	511	521	530	539	549
463		558	567	577	586	596	[illegible]	614	624	633	642
464		652	661	671	680	689	699	708	717	727	736
465		745	755	764	773	783	792	801	811	820	829
466		839	848	857	867	876	885	894	904	913	922
467		932	941	950	960	969	978	987	997	*006	*015
468	67	025	034	043	052	062	071	080	089	099	108
469		117	127	136	145	154	164	173	182	191	201
470		210	219	228	237	247	256	265	274	284	293
471		302	[illegible]	321	330	339	348	357	367	376	385
472		394	403	413	422	431	440	449	459	468	477
473		486	495	504	514	523	532	541	550	560	569
474		578	587	596	605	614	624	633	642	651	660
475		669	679	688	697	706	715	724	733	742	752
476		761	770	779	788	797	806	815	825	834	843
477		852	861	870	[illegible]	[illegible]	897	906	916	925	934
478		943	952	961	970	979	988	997	*006	*015	*024
479	68	034	043	052	061	070	079	088	097	106	115
[illegible]		124	133	142	151	160	[illegible]	178	187	196	205
481		215	224	233	242	251	260	269	278	287	296
482		305	314	323	332	341	350	359	368	377	386
483		395	404	413	422	431	440	449	458	467	476
484		485	494	502	511	520	529	538	547	556	565
485		574	583	592	601	610	619	628	637	646	655
486		664	673	681	690	699	708	717	726	735	744
487		753	762	771	780	789	797	806	815	824	833
488		842	851	860	869	878	886	895	904	913	922
489		931	940	949	958	966	975	984	993	*002	*011
490	69	020	028	037	046	055	064	073	082	090	099
491		108	117	126	135	144	152	162	170	179	188
492		197	205	214	223	232	241	249	258	267	276
493		285	294	302	311	320	329	338	346	355	364
494		373	381	390	399	408	417	425	434	443	452
495		461	469	478	487	496	504	513	522	531	539
496		548	557	566	574	583	592	601	609	618	627
497		636	644	653	662	671	679	688	697	706	714
498		723	732	740	749	758	767	775	784	793	801
499		810	819	827	836	845	854	862	871	880	888
500		897	906	914	923	932	940	949	958	966	975
N	L.	0	1	2	3	4	5	6	7	8	9

P. P.

	10
1	[illegible]
2	2.0
3	3.0
4	4.0
5	5.0
6	6.0
7	7.0
8	8.0
9	9.0

	9
1	[illegible]
2	1.8
3	2.7
4	3.6
5	4.5
6	5.4
7	6.3
8	7.2
9	8.1

Num. 500 to 539. Log. 698 to 732.

N	L	0	1	[illegible]	3	4	5	6	7	8	9
500	69	897	906	914	922	932	940	949	958	966	975
501		984	992	*001	*010	*018	*027	*036	*044	*053	*062
502	70	070	079	088	096	105	114	122	131	140	148
503		157	165	174	183	191	200	209	217	226	234
504		243	252	260	269	278	286	295	303	312	321
505		329	338	346	355	364	372	381	389	398	406
506		415	424	432	441	449	458	467	475	484	492
507		501	509	518	526	535	544	552	561	569	578
508		586	595	603	612	621	629	638	646	655	663
509		672	680	689	697	706	714	723	731	740	749
510		757	766	774	783	791	800	808	817	825	834
511		842	851	859	868	876	885	893	902	910	919
512		927	935	944	952	961	969	978	986	995	*003
513	71	012	020	029	037	046	054	063	071	079	088
514		096	105	113	122	130	139	147	155	164	172
515		181	189	198	206	214	223	231	240	248	257
516		265	273	282	290	299	307	315	324	332	341
517		349	357	366	374	383	391	399	408	416	425
518		433	441	450	458	466	475	483	492	500	508
519		517	525	533	542	550	559	567	575	584	592
520		600	609	617	625	634	642	650	659	667	675
521		684	692	700	709	717	725	734	742	750	759
522		767	775	784	792	800	809	817	825	834	842
523		850	858	867	875	883	892	900	908	917	925
524		933	941	950	958	966	975	983	991	999	*008
525	72	016	024	032	041	049	057	066	074	082	090
526		099	107	115	123	132	140	148	156	165	173
527		181	189	198	[illegible]	214	222	230	239	247	255
528		263	272	280	288	296	304	313	321	329	337
529		346	354	362	370	378	387	395	403	411	419
530		428	436	444	452	460	469	477	485	493	501
531		509	518	526	534	542	550	558	567	575	583
532		591	599	607	616	624	632	640	648	656	665
533		673	681	689	697	705	713	722	730	738	746
534		754	762	770	779	787	795	803	811	819	827
535		835	843	852	860	868	876	884	892	900	908
536		916	925	933	941	949	957	965	973	981	989
537		997	*006	*014	*022	*030	*038	*046	*054	062	*070
538	73	078	086	094	102	111	119	127	135	143	151
539		159	167	175	183	191	199	207	215	223	231
540		239	247	255	263	272	280	288	296	304	312
N	L	0	1	2	3	4	5	6	7	8	9

P. P.

	9
1	0.9
2	1.8
3	2.7
4	3.6
5	4.5
6	5.4
7	6.3
8	7.2
9	8.1

	8
1	0.8
2	1.6
3	2.4
4	3.2
5	4.0
6	4.8
7	5.6
8	6.4
9	7.2

Num. 540 to 579. Log. 732 to 763.

N	L	0	1	2	3	4	5	6	7	8	9
540	73	239	247	255	263	272	280	288	296	304	312
541		320	328	336	344	352	[illegible]	368	376	384	392
542		400	408	416	424	432	440	448	456	464	472
543		480	488	496	504	512	520	528	536	544	552
544		560	568	576	584	592	600	608	616	624	632
545		640	648	656	664	672	679	687	695	703	711
546		719	727	735	743	751	759	767	775	783	791
547		799	807	815	823	830	838	846	854	862	870
548		878	886	894	902	910	918	926	933	941	949
549		957	965	[illegible]	981	989	997	*005	*013	*020	*028
550	74	036	044	052	060	068	076	084	092	099	107
551		115	123	131	139	147	155	162	170	178	186
552		194	202	210	218	[illegible]	233	241	249	257	265
553		273	280	288	296	304	312	320	327	335	343
554		351	359	[illegible]	374	382	390	398	406	414	421
555		429	437	445	453	461	468	476	484	492	500
556		507	515	523	531	539	547	554	562	570	578
557		586	593	601	609	617	624	632	640	648	656
558		663	671	679	687	695	702	710	718	726	733
559		741	749	757	764	772	780	788	796	803	811
560		819	827	834	842	850	858	865	873	881	889
561		896	904	912	920	927	935	943	950	958	966
562		974	981	989	997	*005	*012	*020	*028	*035	*043
563	75	051	059	066	074	082	089	097	105	113	120
564		128	136	143	151	159	166	174	182	189	197
565		205	213	220	228	236	243	251	259	266	274
566		282	289	297	305	312	320	328	335	343	351
567		358	366	374	381	389	397	404	412	420	427
568		435	442	450	458	465	473	481	488	496	504
569		511	519	526	534	542	549	557	565	572	580
570		587	595	603	610	618	626	633	641	648	656
571		664	671	679	686	694	702	709	717	724	732
572		740	747	755	762	770	778	785	793	800	808
573		815	823	831	838	846	853	861	868	876	884
574		891	899	906	914	921	929	937	944	952	959
575		967	974	982	989	997	*005	*012	*020	*027	*035
576	76	042	050	057	065	072	080	087	095	103	110
577		118	125	133	140	148	155	163	170	178	185
578		193	200	208	215	223	230	238	245	253	260
579		268	275	283	290	298	305	313	320	328	335
580		343	350	358	365	373	380	388	395	403	410
N	L	0	1	2	3	4	5	6	7	8	9

P. P.

	8
1	0.8
2	1.6
3	2.4
4	3.2
5	4.0
6	4.8
7	5.6
8	6.4
9	7.2

	7
1	0.7
2	1.4
3	2.1
4	2.8
5	3.5
6	4.2
7	4.9
8	5.6
9	6.3

Num. 580 to 619. Log. 763 to 792.

L.	0	1	2	3	4	5	6	7	8	9
76	343	350	358	365	373	380	388	395	403	410
	418	425	433	440	448	455	462	470	477	485
	492	500	507	515	522	530	537	545	552	559
	567	574	582	589	597	604	612	619	626	634
	641	649	656	664	671	678	686	693	701	708
	716	723	730	738	745	753	760	768	775	782
	790	797	806	812	819	827	834	842	849	856
	864	871	879	886	893	901	908	916	923	930
	938	945	953	960	967	975	982	989	997	*004
77	012	019	026	034	041	048	056	063	070	078
	085	093	100	107	115	122	129	137	144	151
	159	166	173	181	188	195	203	210	217	225
	232	240	247	254	262	269	276	283	291	298
	305	[illegible]	320	327	335	342	349	357	364	371
	379	386	393	401	408	415	422	430	437	444
	452	459	466	474	481	488	495	503	510	517
	525	532	539	546	554	561	568	576	583	590
	597	605	612	619	627	634	641	648	656	663
	670	677	685	692	699	706	714	721	728	735
	743	750	757	764	772	779	786	793	801	808
	815	822	830	837	844	851	859	866	873	880
	887	895	902	909	916	924	931	938	945	952
	960	967	974	981	988	996	*003	*010	*017	*025
78	032	039	046	053	061	068	075	082	089	097
	104	111	118	125	132	140	147	154	161	168
	176	183	190	197	204	211	219	226	233	240
	247	254	262	269	276	283	290	297	305	312
	319	326	333	340	347	355	362	369	376	383
	390	398	405	412	419	426	433	440	447	455
	462	469	476	483	490	497	504	512	519	526
	533	540	547	554	561	[illegible]	576	583	590	597
	604	611	618	625	633	640	647	654	661	668
	675	682	689	696	704	711	718	725	732	739
	746	753	760	767	774	781	789	796	802	810
	817	824	831	838	845	852	859	866	873	880
	888	895	902	909	916	923	930	937	944	951
	958	965	972	979	986	993	*000	*007	*014	*021
79	029	036	043	050	057	064	071	078	085	092
	099	106	113	120	127	134	141	148	155	162
	169	176	183	190	197	204	211	218	225	232
	239	246	253	260	267	274	281	288	295	302
L	0	1	2	3	4	5	6	7	8	9

P. P.

	8		7
1	0.8	1	0.7
2	1.6	2	1.4
3	2.4	[illegible]	2.1
4	3.2	4	2.8
5	4.0	5	3.5
6	4.8	6	4.2
7	5.6	7	4.9
8	6.4	8	5.6
9	7.2	9	6.3

Num. 620 to 659. Log. 792 to 819.

N	L	0	1	2	3	4	5	6	7	8	9
620	79	239	246	253	260	267	274	281	288	295	302
621		309	316	323	330	337	344	351	358	365	372
622		379	386	393	400	407	414	421	428	435	442
623		449	456	463	470	477	484	491	498	505	511
624		518	525	532	539	546	553	560	567	574	581
625		588	595	602	609	616	623	630	637	644	650
626		657	664	671	678	685	692	699	706	713	720
627		727	734	741	748	754	761	768	775	782	789
628		796	803	810	817	824	831	837	844	851	858
629		865	872	879	886	893	900	906	913	920	927
630		934	941	948	955	962	969	975	982	989	996
631	80	003	010	017	024	030	037	044	051	058	065
632		072	079	085	092	099	106	113	120	127	134
633		140	147	154	161	168	175	182	188	195	202
634		209	216	223	229	236	243	250	257	264	271
635		277	284	291	298	305	312	318	325	332	339
636		346	353	359	366	373	380	387	393	400	407
637		414	421	428	434	441	448	455	462	468	475
638		482	489	496	502	509	516	523	530	536	543
639		550	557	564	570	577	584	591	598	604	611
640		618	625	632	638	645	652	659	665	672	679
641		686	693	699	706	713	720	726	733	740	747
642		754	760	767	774	781	787	794	801	808	814
643		821	828	835	841	848	855	862	868	875	882
644		889	895	902	909	916	922	929	936	943	949
645		956	963	969	976	983	990	996	*003	*010	*017
646	81	023	030	037	043	050	057	064	070	077	084
647		090	097	104	111	117	124	131	137	144	151
648		158	164	171	178	184	191	198	204	211	218
649		224	231	238	245	251	258	265	271	278	285
650		291	298	305	311	318	325	331	338	345	351
651		358	365	371	378	385	391	398	405	411	418
652		425	431	438	445	451	458	465	471	478	485
653		491	498	505	511	518	525	531	538	544	551
654		558	564	571	578	584	591	598	604	611	617
655		624	631	637	644	651	657	664	671	677	684
656		690	697	704	710	717	723	730	737	743	750
657		757	763	770	776	783	790	796	803	809	816
658		823	829	836	842	849	856	862	869	875	882
659		889	895	902	908	915	921	928	935	941	948
660		954	961	968	974	981	987	994	*000	*007	*014
N	L	0	1	2	3	4	5	6	7	8	9

P. P.

	7
1	0.7
2	1.4
3	2.1
4	2.8
5	3.5
6	4.2
7	4.9
8	5.6
9	6.3

Num. 660 to 699. Log. 819 to 845.

N	L	0	1	2	3	4	5	6	7	8	9
660	81	954	961	968	974	981	987	994	*000	*007	*014
661	82	020	027	033	040	046	053	060	066	073	079
662		086	092	099	105	112	119	125	132	138	145
663		151	158	164	171	178	184	191	197	204	210
664		217	223	230	236	243	249	256	263	269	276
665		282	289	295	302	308	315	321	328	334	341
666		347	354	360	367	373	380	387	393	400	406
667		413	419	426	432	439	445	452	458	465	471
668		478	484	491	497	504	510	517	523	530	536
669		543	549	556	562	569	575	582	588	595	601
670		607	614	[redacted]	627	633	640	646	653	659	666
671		672	679	685	692	698	705	711	718	724	730
672		737	743	750	756	763	769	776	782	789	795
673		802	808	814	821	827	834	840	847	853	860
674		866	872	879	885	892	898	905	911	918	924
675		930	937	943	950	956	963	969	975	982	988
676		995	*001	*008	*014	*020	*027	*033	*040	*046	*052
677	83	059	065	072	078	085	091	097	104	110	117
678		123	129	136	142	149	155	161	168	174	181
679		187	193	200	[redacted]	[redacted]	219	225	232	238	245
680		251	257	264	270	276	283	289	296	302	308
681		315	321	327	334	340	347	353	359	366	372
682		378	385	391	398	404	410	417	423	429	436
683		442	448	455	461	467	474	480	487	493	499
684		506	512	518	525	531	[redacted]	544	550	556	563
685		569	575	582	588	594	601	607	613	620	626
686		632	639	645	651	658	664	670	677	683	689
687		696	702	708	715	721	727	734	740	746	753
688		759	765	771	778	784	790	797	803	809	816
689		822	[redacted]	835	841	847	853	860	866	872	879
690		885	891	897	904	910	916	923	929	935	942
691		948	954	960	967	973	979	985	992	998	*004
692	84	011	017	023	029	036	042	048	055	061	067
693		073	080	[redacted]	092	098	105	111	117	123	130
694		136	142	148	155	161	167	173	180	186	192
695		[redacted]	205	211	217	223	230	236	242	248	255
696		261	267	273	280	286	292	298	305	311	317
697		323	330	336	342	348	354	361	367	373	379
698		386	392	398	404	410	417	423	429	435	442
699		448	454	460	466	473	479	485	491	497	504
700		*510*	*516*	*522*	*528*	*535*	*541*	*547*	*553*	*559*	*566*
N	*L.*	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*

P. P.

	7
1	0.7
2	1.4
3	2.1
4	2.8
5	3.5
6	4.2
7	4.9
8	5.6
9	6.3

	6
1	0.6
2	1.2
3	1.8
4	2.4
5	3.0
6	3.6
7	4.2
8	4.8
9	5.4

P. P.

Num 700 to 739 Log. 845 to 869.

N	L	0	1	2	3	4	5	6	7	8	9	P. P.
700	84	510	516	522	528	535	541	547	553	559	566	
701		572	578	584	590	597	603	609	615	621	628	
702		634	640	646	652	658	665	671	677	683	689	
703		696	702	708	714	720	726	733	739	745	751	
704		757	763	770	776	782	788	794	[illegible]	807	813	
705		819	825	831	837	844	850	856	862	[illegible]	874	
706		880	887	893	[illegible]	905	911	917	924	930	936	
707		942	948	954	960	967	973	979	985	991	997	
708	85	003	009	016	022	028	034	040	046	052	058	
709		065	071	077	083	089	[illegible]	[illegible]	107	114	120	
710		126	132	138	144	150	156	163	169	175	181	
711		187	193	199	205	211	217	224	230	236	242	
712		248	254	260	266	272	278	285	291	297	303	
713		309	315	321	327	333	339	345	352	358	364	
714		370	376	382	388	394	400	406	412	418	425	
715		431	437	443	449	455	461	467	473	479	485	
716		491	497	503	509	516	522	528	534	540	546	
717		552	558	564	570	576	582	588	594	600	[illegible]	
718		612	618	625	631	637	643	649	655	661	667	
719		673	679	685	691	697	703	709	715	721	727	
720		733	739	745	751	757	763	769	775	781	788	
721		794	800	806	812	818	824	830	836	842	848	
722		854	860	866	872	878	884	890	896	902	908	
723		914	920	926	932	938	944	950	956	962	968	
724		974	980	986	992	998	*004	*010	*016	*022	*028	
725	86	034	040	046	052	058	064	070	076	082	088	
726		094	100	106	112	118	124	130	136	141	147	
727		153	159	165	171	177	183	189	195	201	207	
728		213	219	225	231	237	243	249	255	261	267	
729		273	279	285	291	297	303	308	314	320	326	
730		332	338	344	350	356	362	368	374	380	386	
731		392	398	404	410	415	421	427	433	439	445	
732		451	457	463	469	475	481	487	493	499	504	
733		510	516	522	528	534	540	546	552	558	564	
734		570	576	581	587	593	599	605	611	617	623	
735		629	635	641	646	652	658	664	670	676	682	
736		688	694	700	705	711	717	723	729	735	741	
737		747	753	759	764	770	776	782	788	794	800	
738		806	812	817	823	829	835	841	847	853	859	
739		864	870	876	882	888	894	900	906	911	917	
740		923	929	935	941	947	953	958	964	970	976	
N	*L*	0	1	2	3	4	5	6	7	8	9	P. P.

P. P.

	6
1	0.6
2	1.2
3	1.8
4	2.4
5	3.0
6	3.6
7	4.2
8	4.8
9	5.4

Num. 740 to 779. Log. 869 to 892.

N	L	0	1	2	3	4	5	6	7	8	9	P. P.
740	86	923	929	935	941	947	953	958	964	970	976	
741		982	988	994	999	*005	*011	*017	*023	*029	*035	
742	87	040	046	052	058	064	070	075	081	087	093	
743		099	105	111	116	122	128	134	140	146	151	
744		157	163	169	175	181	186	192	198	204	210	
745		216	221	227	233	239	245	251	256	262	268	
746		274	280	286	291	297	303	309	315	320	326	
747		332	338	344	349	355	361	367	373	379	384	
748		390	396	402	408	413	419	425	431	437	442	
749		448	454	460	466	471	477	483	489	495	500	
750		506	512	518	523	529	535	541	547	552	558	
751		564	570	576	581	587	593	599	604	610	616	
752		622	628	633	639	645	651	656	662	668	674	
753		679	685	691	697	703	708	714	720	726	731	
754		737	743	749	754	760	766	772	777	783	789	
755		795	800	806	812	818	823	829	835	841	846	
756		852	858	864	869	875	881	887	892	898	904	
757		910	915	921	927	933	938	944	950	955	961	
758		967	973	978	984	990	996	*001	*007	*013	*018	
759	88	024	030	036	041	047	053	058	064	070	076	
760		081	087	093	098	104	110	116	121	127	133	
761		138	144	150	156	161	167	173	178	184	190	
762		195	201	207	213	218	224	230	235	241	247	
763		252	258	264	270	275	281	287	292	298	304	
764		309	315	321	326	332	338	343	349	355	360	
765		366	372	377	383	389	[illegible]	400	406	412	417	
766		423	429	434	440	446	451	457	463	468	474	
767		480	485	491	497	502	508	513	519	525	530	
768		536	542	547	553	559	564	570	576	581	587	
769		593	598	604	610	615	[illegible]	627	632	638	643	
770		649	655	660	666	672	677	683	689	694	700	
771		705	711	717	722	728	734	739	745	750	756	
772		762	767	773	779	784	790	795	801	807	812	
773		818	824	829	835	840	846	852	857	863	868	
774		874	880	885	891	897	902	908	913	919	925	
775		930	936	941	947	953	958	964	969	975	981	
776		986	992	997	*003	*009	*014	*020	*025	*031	*037	
777	89	042	048	053	059	064	070	076	081	087	092	
778		098	104	109	115	120	126	131	137	143	148	
779		154	159	165	170	176	182	187	193	198	204	
780		209	215	221	226	232	237	243	248	254	260	
N	L	0	1	2	3	4	5	6	7	8	9	P. P.

P. P.

	6
1	0.6
2	1.2
3	1.8
4	2.4
5	3.0
6	3.6
7	4.2
8	4.8
9	5.4

Num. 780 to 819. Log. 892 to 913.

N	L	0	1	2	3	4	5	6	7	8	9	P. P.
780	89	209	215	221	226	232	237	243	248	254	260	
781		265	271	276	282	287	293	298	304	310	315	
782		321	326	332	337	343	348	354	360	365	371	
783		376	382	387	393	398	404	409	415	421	426	
784		432	437	443	448	454	459	465	470	476	481	
785		487	492	498	504	509	515	520	526	531	537	
786		542	548	553	559	564	570	575	581	586	592	
787		597	603	609	614	620	625	631	636	642	647	
788		653	658	664	669	675	680	686	691	697	702	
789		708	713	719	724	730	735	741	746	752	757	
790		763	768	774	779	785	[illegible]	796	801	[illegible]	812	
791		818	823	829	834	840	845	851	856	862	867	
792		873	878	883	889	894	900	905	911	916	922	
793		927	933	938	944	949	955	960	966	971	977	
794		982	988	993	998	*004	*009	*015	*020	*026	*031	
795	90	037	042	048	053	059	064	069	075	080	086	
796		091	097	102	108	113	119	124	129	135	140	
797		146	151	157	162	168	173	179	184	189	195	
798		200	206	211	217	222	227	233	238	244	249	
799		255	260	266	271	276	282	287	293	298	304	
800		309	314	320	325	331	336	342	347	352	358	
801		363	369	374	380	385	390	396	401	407	412	
802		417	423	428	434	439	445	450	455	461	466	
803		472	477	482	488	493	499	504	509	515	520	
804		526	531	536	542	547	553	558	563	569	574	
805		580	585	590	596	601	607	612	617	623	628	
806		634	639	644	650	655	660	666	671	677	682	
807		687	693	698	703	709	714	720	725	730	736	
808		741	747	752	757	763	768	773	779	784	789	
809		795	800	806	811	816	822	827	832	838	843	
810		849	854	859	865	870	875	881	886	891	897	
811		902	907	913	918	924	929	934	940	945	950	
812		956	961	966	972	977	982	988	993	998	*004	
813	91	009	014	020	025	030	036	041	046	052	057	
814		062	068	073	078	084	089	094	100	105	110	
815		116	121	126	132	137	142	148	153	158	164	
816		169	174	180	185	190	196	201	206	212	217	
817		222	228	233	238	243	249	254	259	265	270	
818		275	281	286	291	297	302	307	312	318	323	
819		328	334	339	344	350	355	360	365	371	376	
820		381	387	393	397	403	408	413	418	424	429	
	L	0	1	2	3	4	5	6	7	8	9	P. P.

	5
1	0.5
2	1.0
3	1.5
4	2.0
5	2.5
6	3.0
7	3.5
8	4.0
9	4.5

Num. 820 to 859. Log. 913 to 934.

N	L	0	1	2	3	4	5	6	7	8	9
820	91	381	387	392	397	403	408	413	418	424	429
821		434	440	445	450	455	461	466	471	477	482
822		487	492	498	503	508	514	519	524	529	535
823		540	545	551	556	561	566	572	577	582	587
824		593	598	603	609	614	619	624	630	635	640
825		645	651	656	661	[illegible]	672	677	682	687	693
826		698	703	709	714	719	724	730	735	740	745
827		751	756	761	766	772	777	782	787	793	798
828		803	808	814	819	824	829	834	840	845	850
829		855	861	866	871	876	[illegible]	887	892	897	903
830		908	913	918	924	929	934	939	944	950	955
831		960	965	971	976	981	986	991	997	*002	*007
832	92	012	018	023	028	033	[illegible]	044	049	054	059
833		065	070	075	080	085	091	096	101	106	111
834		117	122	127	132	137	143	148	153	158	163
835		169	174	179	184	189	195	200	205	210	215
836		221	226	231	236	241	247	252	257	262	267
837		273	278	283	288	293	298	304	309	314	319
838		324	330	335	340	345	[illegible]	355	361	366	371
839		376	[illegible]	387	392	397	402	[illegible]	412	418	423
840		428	433	438	443	449	454	459	464	469	474
841		480	485	490	495	500	505	511	516	521	526
842		531	536	542	547	552	557	562	567	572	578
843		583	588	593	598	603	609	614	619	624	629
844		634	639	645	650	655	660	665	670	675	681
845		686	691	696	701	706	711	716	722	727	732
846		737	742	747	752	758	763	768	773	778	783
847		788	793	799	804	809	814	819	824	829	834
848		840	845	850	855	860	865	870	875	881	886
849		891	896	901	906	911	[illegible]	921	927	932	937
850		942	947	952	957	962	967	973	978	983	988
851		993	998	*003	*008	*013	*018	*024	*029	*034	*039
852	93	044	049	054	059	064	069	075	080	085	090
853		095	100	105	110	115	120	125	131	136	141
854		146	151	156	161	166	171	176	181	186	192
855		197	202	207	212	217	222	227	232	237	242
856		247	252	258	263	[illegible]	273	278	283	288	293
857		298	303	308	313	318	323	328	334	339	344
858		349	354	359	364	369	374	379	384	389	394
859		399	404	409	414	420	425	430	435	440	445
860		450	455	460	465	470	475	480	485	490	495
N	L	0	1	2	3	4	5	6	7	8	9

P. P.

	5
1	0.5
2	1.0
3	1.5
4	2.0
5	2.5
6	3.0
7	3.5
8	4.0
9	4.5

Num. 860 to 899. Log. 934 to 954.

N	L	0	1	2	3	4	5	6	7	8	9
860	93	450	455	460	465	470	475	480	485	490	495
861		500	505	510	515	520	526	531	536	541	546
862		551	556	561	566	571	576	581	586	591	596
863		601	606	611	616	621	626	631	636	641	646
864		651	656	661	666	671	676	682	687	692	697
865		702	707	712	717	722	727	732	737	742	747
866		752	757	762	767	772	777	782	787	792	797
867		802	807	812	817	822	827	832	[illegible]	842	847
868		852	857	862	867	872	877	882	887	892	897
869		902	907	912	917	922	927	932	937	942	947
870		952	957	962	967	972	977	982	987	992	[illegible]
871	94	002	007	012	017	022	027	032	037	042	047
872		052	057	062	[illegible]	072	077	082	086	091	[illegible]
873		101	106	111	116	121	126	131	136	141	146
874		151	156	161	166	171	176	181	186	191	196
875		201	206	211	216	221	226	231	[illegible]	240	245
876		250	255	260	265	270	275	280	285	290	295
877		300	305	310	315	320	325	330	335	340	345
878		349	354	359	364	369	374	379	384	389	394
879		399	404	409	414	419	424	429	433	438	443
880		448	453	458	463	468	473	478	483	488	493
881		498	503	507	512	517	522	527	532	537	542
882		547	552	557	562	567	571	576	581	586	591
883		596	601	606	611	616	621	626	630	635	640
884		645	650	655	660	665	670	675	680	685	689
885		694	699	704	709	714	719	724	729	734	738
886		743	748	753	758	763	768	773	778	783	787
887		792	797	802	807	812	817	822	827	832	836
888		841	846	851	856	861	866	871	876	880	885
889		890	895	900	905	910	915	919	924	929	934
890		939	944	949	954	959	963	968	973	978	983
891		988	993	998	*002	*007	*012	*017	*022	*027	*032
892	95	036	041	046	051	056	061	066	071	075	080
893		085	090	095	100	105	109	114	119	124	129
894		134	139	143	148	153	158	163	168	173	177
895		182	187	192	197	202	207	211	216	221	226
896		231	236	240	245	250	255	260	265	270	274
897		279	284	289	294	299	303	308	313	318	323
898		328	332	337	342	347	352	357	361	366	371
899		376	381	386	390	395	400	405	410	415	419
900		424	429	434	439	444	448	453	458	463	468
N	L	0	1	2	3	4	5	6	7	8	9

P. P.

	5
1	0.5
2	1.0
3	1.5
4	2.0
5	2.5
6	3.0
7	3.5
8	4.0
9	4.5

Num. 900 to 939. Log. 954 to 973.

N	L.	0	1	2	3	4	5	6	7	8	9
900	95	424	429	434	439	444	448	453	458	463	468
901		472	477	482	487	492	497	501	506	511	516
902		521	525	530	535	540	545	550	554	559	564
903		569	574	578	583	588	593	598	602	607	612
904		617	622	626	631	636	641	646	650	655	660
905		665	670	674	679	684	689	694	698	703	708
906		713	718	722	727	732	737	742	746	751	756
907		761	766	770	775	[illegible]	785	789	794	799	804
908		809	813	818	823	828	832	837	842	847	852
909		856	861	866	871	875	880	885	890	895	899
910		904	909	914	918	[illegible]	928	933	938	942	947
911		952	957	961	966	971	976	980	985	990	995
912		999	*004	*009	*014	*019	*023	*028	*033	*038	*042
913	96	047	052	057	061	066	071	076	080	085	090
914		095	099	[illegible]	109	114	118	123	128	133	137
915		142	147	152	156	161	166	171	175	180	185
916		190	194	199	204	209	213	218	223	227	232
917		237	242	246	251	256	261	265	270	275	280
918		284	289	294	298	303	308	313	317	322	327
919		332	336	341	346	350	355	360	365	369	374
920		379	384	388	393	398	402	407	412	417	421
921		426	431	435	440	445	450	454	459	464	468
922		473	478	483	487	492	497	501	506	511	515
923		520	525	530	534	539	544	548	553	558	562
924		567	572	577	581	586	591	595	600	605	609
925		614	619	624	628	633	638	642	647	652	656
926		661	666	670	675	680	685	689	694	699	[illegible]
927		708	713	717	722	727	731	736	741	745	750
928		755	759	764	769	774	778	783	788	792	797
929		802	806	811	816	820	825	830	834	839	844
930		848	853	858	862	867	872	876	881	886	[illegible]
931		895	900	904	909	914	918	923	928	932	937
932		942	946	951	956	960	965	970	974	979	984
933		988	993	997	*002	*007	*011	*016	*021	*025	*030
934	97	035	039	044	049	053	058	063	067	072	077
935		081	086	090	095	100	104	109	114	118	123
936		128	132	137	142	146	151	155	160	165	169
937		174	179	183	188	192	197	202	206	211	216
938		220	225	230	234	239	243	248	253	257	262
939		267	271	276	280	285	290	294	299	304	308
940		313	317	322	327	331	336	340	345	350	354
N	*L*	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*

P. P.

	5
1	0.5
2	1.0
3	1.5
4	2.0
5	2.5
6	3.0
7	3.5
8	4.0
9	4.5

Num. 940 to 979. Log. 973 to 991.

N	L.	0	1	2	3	4	5	6	7	8	9
940	97	313	317	322	327	331	[illegible]	340	345	350	354
941		359	364	368	373	377	382	387	391	396	400
942		405	410	414	419	424	428	433	437	442	447
943		451	456	460	465	470	474	479	483	488	493
944		497	502	506	511	516	520	525	529	534	539
945		543	548	552	557	562	566	571	575	580	585
946		589	594	598	603	607	612	617	621	626	630
947		635	640	644	649	653	658	663	667	672	676
948		681	685	690	695	699	704	[illegible]	713	717	722
949		727	731	736	740	745	749	754	759	763	768
950		772	777	782	786	791	795	800	[illegible]	809	813
951		818	823	827	832	836	841	845	850	855	859
952		864	868	873	877	882	886	891	896	900	905
953		909	914	918	923	928	932	937	941	946	950
954		955	959	964	968	973	978	982	987	991	996
955	98	000	005	009	014	019	023	[illegible]	032	037	041
956		046	050	055	059	064	068	073	078	082	087
957		091	096	100	105	109	114	118	123	127	132
958		137	141	146	150	155	159	164	168	173	177
959		182	186	191	195	200	204	209	214	218	223
960		227	232	236	241	245	250	254	259	263	268
961		272	277	281	286	290	295	299	304	308	313
962		318	322	327	331	336	340	345	349	354	358
963		363	367	372	376	381	385	390	394	399	403
964		408	412	417	421	426	430	435	439	444	448
965		453	457	462	466	471	475	480	484	489	493
966		498	502	507	511	516	520	525	529	534	538
967		543	547	552	556	561	565	570	574	579	583
968		588	592	597	601	605	610	614	619	623	628
969		632	637	641	646	650	655	659	664	668	673
970		677	682	686	691	695	700	704	709	713	717
971		722	726	731	735	740	744	749	753	758	762
972		767	771	776	780	784	789	793	798	802	807
973		811	816	820	825	829	834	838	843	847	851
974		856	860	865	869	874	878	883	887	892	896
975		900	905	909	914	918	923	927	932	936	941
976		945	949	954	958	963	967	972	976	981	985
977		989	994	998	*003	*007	*012	*016	*021	*025	*029
978	99	034	038	043	047	052	056	061	065	069	074
979		078	083	087	092	096	100	105	109	114	118
980		123	127	131	136	140	145	149	154	158	162
N	L	0	1	2	3	4	5	6	7	8	9

P. P.

	5
1	0.5
2	1.0
3	1.5
4	2.0
5	2.5
6	3.0
7	3.5
8	4.0
9	4.5

	4
1	0.4
2	0.8
3	1.2
4	1.6
5	2.0
6	2.4
7	2.8
8	3.2
9	3.6

P. P.

Num. 980 to 1000. Log. 991 to 999.

N	L	0	1	2	3	4	5	6	7	8	9	P. P.
980	99	123	127	131	136	140	145	149	154	158	162	
981		167	171	176	180	185	189	193	198	202	207	
982		211	216	220	224	229	233	238	242	247	251	
983		255	260	264	269	273	277	282	286	291	295	
984		300	304	308	313	317	322	326	330	335	339	
985		344	348	352	357	361	366	370	374	379	383	
986		388	392	396	401	405	410	414	419	423	427	
987		432	436	441	445	449	454	458	463	467	471	
988		476	480	484	489	493	498	502	506	511	515	
989		520	524	528	533	537	542	546	550	555	559	**4**
990		564	568	572	577	581	585	590	594	599	603	1 | 0.4
991		607	612	616	621	625	629	634	638	642	647	2 | 0.8
992		651	656	660	664	669	673	677	682	686	691	3 | 1.2
993		695	699	704	708	712	717	721	726	730	734	4 | 1.6
994		739	743	747	752	756	760	765	769	774	778	5 | 2.0
995		782	787	791	795	800	804	808	813	817	822	6 | 2.4
996		826	830	835	839	843	848	852	856	861	865	7 | 2.8
997		870	874	878	883	887	891	896	900	904	909	8 | 3.2
998		913	917	922	926	930	935	939	944	948	952	9 | 3.6
999		957	961	965	970	974	978	983	987	991	996	
1000	000	000	043	087	130	174	217	260	304	347	391	
N	L	0	1	2	3	4	5	6	7	8	9	P. P.

Logarithms of Important Numbers.

Number.	Logarithm.
$\pi = 3.141\ 593$	0.497 150
$\frac{4}{3}\pi = 4.188\ 790$	0.622 089
$\frac{1}{6}\pi = 0.523\ 599$	$\bar{1}.718\ 999$
$\frac{1}{\pi} = 0.318\ 310$	$\bar{1}.502\ 850$
$\pi^2 = 9.869\ 604$	0.994 300
$\frac{1}{\pi^2} = 0.101\ 321$	$\bar{1}.005\ 700$
$\sqrt{\pi} = 1.772\ 454$	0.248 575
$\frac{1}{\sqrt{\pi}} = 0.564\ 190$	$\bar{1}.751\ 425$
$\sqrt[3]{\pi} = 1.464\ 592$	0.165 717
$\frac{1}{\sqrt[3]{\pi}} = 0.682\ 784$	$\bar{1}.834\ 283$
$\sqrt[3]{\frac{6}{\pi}} = 1.240\ 701$	0.093 667

INDEX.

"PARKS PNEUMERCATOR"

The Indicating and Registering portion of the instrument can be installed at any distance either above or below the part of the apparatus connected to the source of pressure.

In marine work, this is preferably, The Captain's Office, Chartroom or Pilot House. (see photograph)

Operating and control valves are an integral part of the instrument itself and the accuracy of the readings can be instantly checked.

Various models are manufactured for Marine, Submarine and Stationary service.

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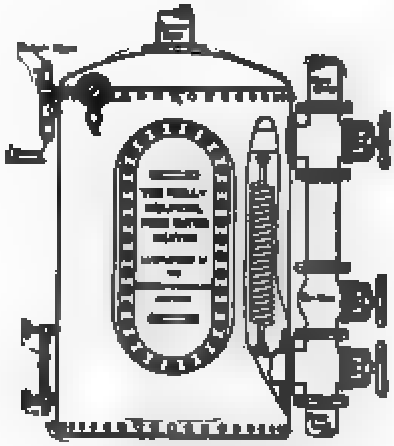
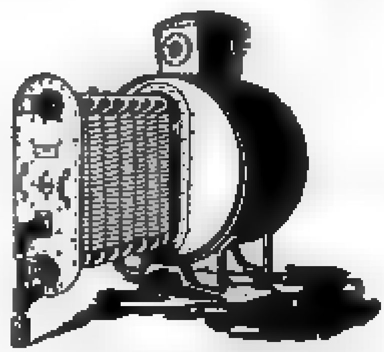
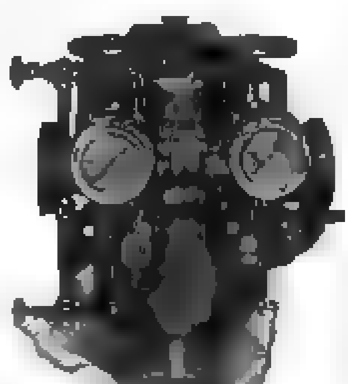


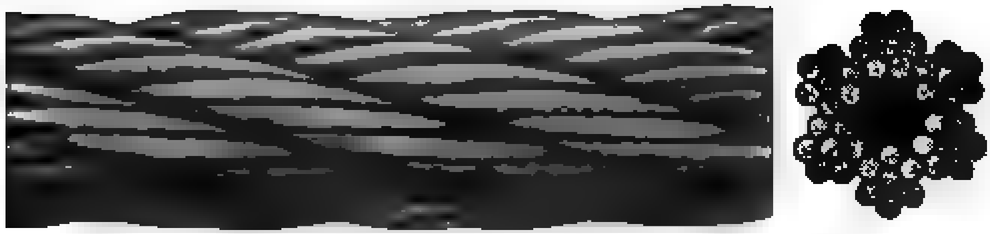
REILLY MULTICOIL FEED WATER HEATER



REILLY MULTICOIL NAVY TYPE EVAPORATOR



G-R MULTISCREEN FEED WATER FILTER



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